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Survey on challenges and solution application of Knuth marith ,Aho Corasick, Wu Moore algorithm in snort intrusion detection system (IDS)

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Abstract

This paper presents different techniques used by intrusion detection system to detect malware, components of snort intrusion detection system and performance bottleneck, challenges faced by some of the system in packet inspection. And also the paper present challenges and performance improvement, of some propose pattern matching algorithm such as Knuth marith, aho - Corasick and algorithms.

Introduction

As a result of vast increase in technology and lack of integrating good security practice in software and hardware design which had leads to backdoors, bugs and e.t.c. A number of network attacks are increasing dramatically, ranging from denial of services, IP spoofing eavesdropping, mitnick,(MITM) man in the middle attack masquerading and malware attacks (Snehal and Jadhav,2010).These attacks have made traditional network security mechanism

ineffective, which requires additional defense mechanism that can analyze, detect and mitigate these attacks.

Knowledge of the intruder

With the rapid growing number of automated tools, discussion group, forums and skill intruders, has lead to the increase in attack sophistication. The knowledge gathered by intruder by taken part in online hackers' forums has resulted in a raise of knowledge needed to exploit computing resources. Furthermore, increasing number of open source or free automated tools used to determine and launch attack in the computing are taken as one among factors that increase the knowledge of attackers, nowadays, intruder does not require any much experience and skills in carrying their activities, because number of system vulnerabilities can be found for free in the internet.

Intrusion

The term intrusion can be described as a violation of security policy of systems with the aims of destroying or de-stabilizing its activities. In other word Intrusion is an unauthorized access to the network computing devices by the legitimate or un-legitimate user. There are different techniques used to intrudes in to a network or get access in to the network of computing device illegally. Some of the popular known network intrusions include IP spoofing, denial of services; port Scanning, WEP cracking, Masquerading and Malware attack. Vulnerabilities in the architectural network system usually seen in the three (3) levels which constitutes, system, network and application may leads to an intrusion in to the system. Therefore, intrusion may be at a network level, system level where an attackers penetrate the operating system of the computer either connected to the internet or else as a standalone system and have control of the computing resource or application level e.g. database or payrolls.

Intrusion Detection System

Nowadays, intrusion detection system is the most widely used and top growing network security technology used by many industries. These systems unlike firewall and other security related systems such as Honey pot are mainly designed to detect any intrusion into a network. According to work by (Rani,2009) many different forms of open source and commercial intrusion detection are obtainable to the best of user requirement e.g. snort, Nitro-Guard and Niksu net detector.(Geddes Linda, 2009) highlighted that it has been estimated that the open source intrusion detection system has higher popularity in middle size industries than the commercial systems as result of high cost, real time support and ability to be configured to suite the user needs and platform implementations. The attractiveness of the open source software in most of our research institution and academic environment resulted from many qualities that open source software has, such as detailed documentation, online forum support and ability to be customized to meet user requirements.

In addition, many objectives are assigned to be achieved while deploying Intrusion detection system one of them is to design the behaviors based on system events that can detect network intruders. The design system operation is basically set to be based on difference phases each of which there is a specific task set to be accomplished. In the data collection phase, all information about system behaviors were gathered and in a pre-processing phase the input data to be used in the IDS system is generated, this is done through pre-processing the network traffic data, also in the training phase, the pre- processed data served as the basis through or from which network user normal behavior is known by the system, and in the detection phase, it allows the attack to be detected by comparing the gathered behavior and that of the present pattern. Also, when the intruder is detected by the IDs system, alert is send to the administrator

(Gascon Hugo, *et. al*, 2011). Generally, the network user behavior is classified using difference techniques. Example, using artificial intelligent and rule induction which had resulted in different types of network intruders. Network throughput is the main factor to consider when designing IDS and these classified IDs must fit with the network rate to function well to detect any intrusion in to the network, without packet dropping and be able to rigorously supervise, monitor and analyzes network inbound and outbound packets. In a higher network architectures, distributed intrusion detection system sensors are used in conjunctions with load balancing traffic splitter to provide load balancing between different sensors. These will ensure minimum used of resources and ease cost of deployment. Similarly, two (2) distinct responses were identified used by most intrusion detection systems If an attack is detected in the network namely passive response or active response (Bahram and Bahrami , 2011). Also, if an attack is detected by ids the responses to this types of attack depends on whether is passive response or active , in an passive mode IDS responses to an attack by the system is, the traffic is not denying access to the network rather the incident is usually recorded in the log file and an alert is generated and send to notify the administrator. While in an active response mode IDs, a reset connection packet is send to allow the packet to be ignored entry in to the network (Shoor and Gore, 2011). The two(2) different types of IDs, Network intrusion detection system and host based intrusion detection system utilizes general concept of detection in deterring an attack either prevention or detection and log before an attack occurs or after and designed of these system is either hardware based or software based. Along, many functions were performed by both network and host-based intrusion detection system in detecting malicious packets, some of these functions includes the ability of the IDS system to monitor and configures security systems (Firewell) based on observed security policy violation or patches and the identify

vulnerabilities on the system. (Ashoor and Gore, 2011).Many intrusive behaviours can be observed and analyzes by these security devices such as may includes illegal connection to a network port or hidden malicious script, the detected event logged as intrusive by to (Young, 2010).

Administrator (Gascon Hugo, *et. al*, 2011) state the usefulness of the collected and logged malicious packets or event as used for further pre-question about the policy violation and policy setting like fire rules re-configurations and ips settings.

Network Intrusion detection system

Network intrusion detection system is deployed in the network segment to observe and analyzes incoming network packets. The captured and analyzed data is used to detect known attacks using the stored patterns or signatures of the database. And also all of illegal activities are detected by simply scanning network traffic, for example illegal connection to the network services such as HTPP SPOP and SMTP. Packets sniffing by IDs system were done by four modules that consistitutes the network IDs architecture namely event modules, data modules, analyze modules and response modules, these modules are used to perform detection work based on the network packet behaviors.

However, According to (Young, 2010) intrusion detection is an act of identifying and logging malicious traffic in a network or host computer from system violations of security policies which may includes illegal connection to a network port or hidden malicious script, the detected intrusion according (Gascon,Hugo et.al,2011) were recorded in the logs file or the system will generate alert and notify the system administrators or logs the event in the logs files. Administrator (Gascon Hugo, *et. al*, 2011) state the usefulness of the collected and logged

malicious packets or event as used for further pre-question about the policy violation and policy setting like fire rules re-configurations

Host-Based Intrusion detection

According to Suman, (2010) defined host-based intrusion detection as software based intrusion detection system usually installed in the host computer that requires specific configuration. Therefore, based on the operating system, the host intrusion detection system is configure to deals with detection of security policy violations by analyzing the host local logs audit files, software calls and other.

Basically, many types of host-based intrusion detection system combined both intrusion detection and prevention functions like in most network intrusion detection systems, these tools can performs detection at both network and host level. HIDS analyzes data originated from local host to find malicious traffic. Many host information are analyzed by HIDS that includes event and kernel logs. Also, it tracks program access to system resource and maintained a match between program abnormal behavior and system normal behavior. McAfee intrusion detection and prevention system is an example of HIDPS used to interrupt system call and network traffic before being executed in the host systems. This is in order to ensure full protection of the system resource and applications i.e. web based application, internet resources, payrolls and operating systems files itself.

Signature based detection technique

Signature detection techniques is an intrusion detection techniques which a record of known attack signature is kept in the database and detect intrusion by comparing signature pattern and a pattern that exist in the packet payload. In these techniques, network packets are search to

indentify malicious byte in its header. In this technique, the signature is very easy to form, for efficient pattern matching to be done a reasonable amount of power is needed in respect to a specific number of rules. In addition, signatures of exploits are generated easily based on the specific service port it communicated with, for examples, system that communicate through the following services Domain name server (DNS), internet control message protocol (ICMP) and SMTP. But fixed behavioral pattern detections, increasing number of novel attack and in-ability to detect self modifying worm and virus has become catastrophic to this techniques (*Jyothsna et. all*, 2011).Similarly, advanced technologies are used to avoid this techniques such as malware encryption, obstication of a malware to produce many variant also increasing in number of attack signatures contributed to the performance degradation (Gascon Hugo *et.al*,2011). In addition, the performance degradation of the IDS during pattern matching is over come by deploying the system in multi processors and multi Gigabit network card. A proposed system based on hardware like Application specific integrated circuit (ASIC), Field programmable Gate array (FPGA) and ternary Addressable memory (TC(Gao, 2006) to enhance the performance of signature pattern matching of the system engine.

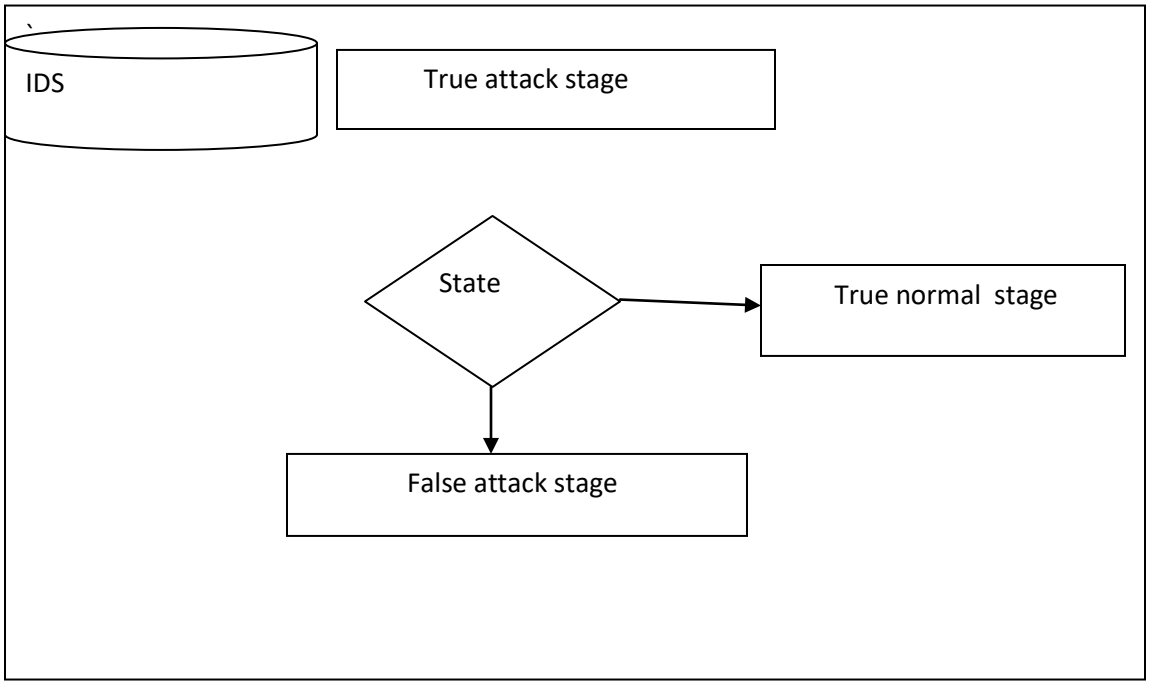


Figure 2.1 Illustrate misuse detection techniques model (Patel, 2008)

In the figure 2.1 given above illustrates the misuse detection model .The model use pre-defined signature pattern defined in its database to detect anomalous packet using pattern matching algorithm. The model above compares normal signature pattern with abnormal define in the IDS dabatase, If a match is found then a response is generated inform of alert or log the incident in the log files.The above model addressed the problems of false negative by updating the model profile (Patel, 2008).

Anomaly based detection techniques

Basically, in anomaly based detection network behavior is learned and the learned network behavior is compared with the incoming network traffic to detect an intrusion (Sandhu *et.al* 2011). In this technique many possibilities are used to detect anomalous behaviors. Data such as Kernel information, system log records .Software Information running information, normal

packet characteristics were collected stored and network throughput change. Therefore, any deviation to this gathered information is recorded as anomalous.The techniques used Metric to measure and detect the deviation of the system behavior , generate and send an alert to the alert modules.

The model development comprises of three different stages namely parameterization, training and detection stage (Ning and Jajodia, 2001).However, the working stile of this technique in contrast to the signature based detection techniques, it defines on some network protocols, it presents a problems in rule setting and produce higher rate of false alarm. The strength of this techniques over signature based engines is, its ability to be able to deter any novel attack whose pattern has deviated from normal traffic pattern (Ning, and Jajodia, 2001).

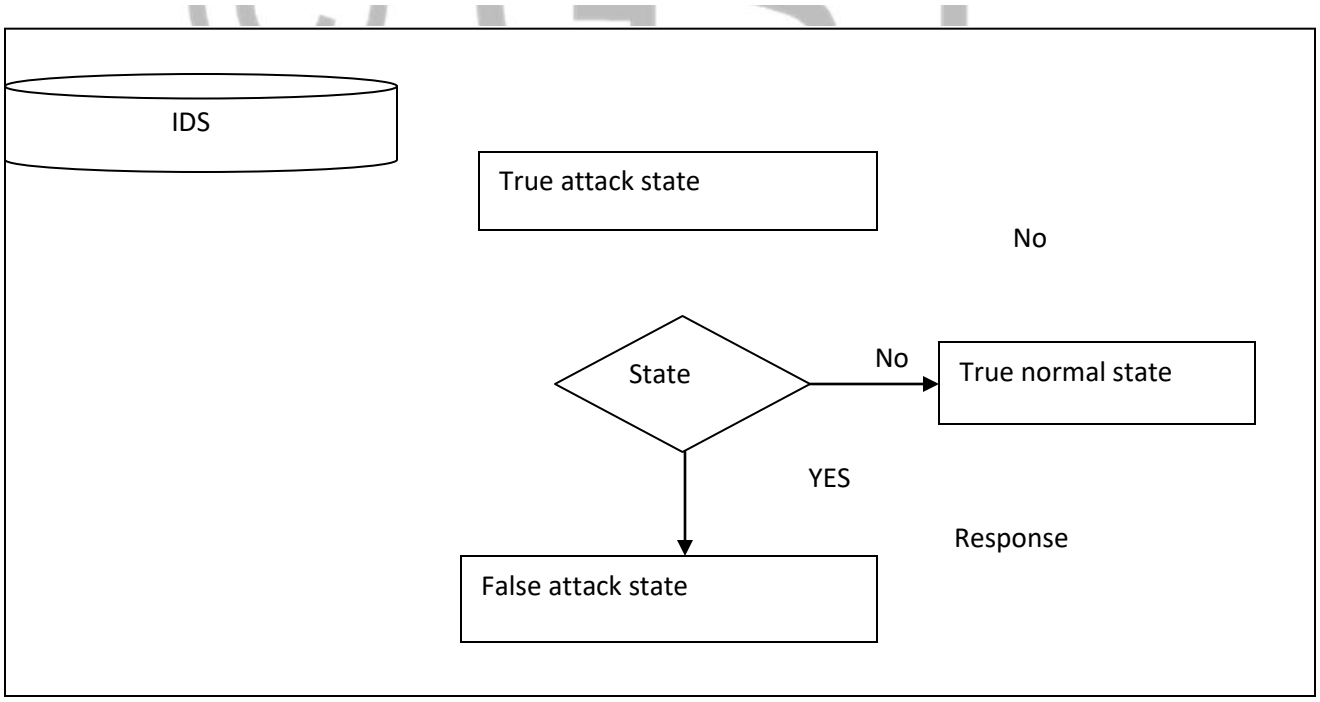


Figure 2.1 Anomalous Detection Techniques Model (Patel,2008)

In the Figure 2.2 given above illustrates the anomalous detection model. The detection is based on the deviation of the model system behavior as described in the section 2.3.5, the incoming data is analyzed and a significant deviations or correlation or similarities are observed and then responses are generated and either log or send to the alerting modules for the system administrator. In addition for the false alarm generated mostly by this model is addressed through profile upgrade and changes made within the system or network traffic behavior observed (Patel, 2008).

Historical background of SNORT

Snort intrusion detection is an open source intrusion detection which is a signature based. Snort tool was originally design as a packet sniffer in 1998 by Marty Roesch which was named APE (Linda Geddes, 2009). Despite the function perform by the APE, Marty Roesch wanted to have a sniffer that can have additional features or that can perform many functions such as ability to function in many different Operating systems platforms. Windows Linux and UNIX are few among the interested operating system platform Marty Roesch wanted to have snort tool working on. Another desire by the Marty Roesch is the ability for the sniffer (APE) to display multiple difference network packets in the unique form. Much advancement on sniffer features come to being including the sniffer ability to not only capture packet but to filter it also. This application is named libpcap. However, In December, 1998, snort become packet storm which has only one thousands and six hundred (1600) lines of code that are compiled in only two files. Marty's uses snort to perform many work such as monitoring his cable modern and debugging his network applications at around January 1999 snort become a fully features signature based detection system. In addition, on December 1999 a new version of snort 1.5 was released, which was used

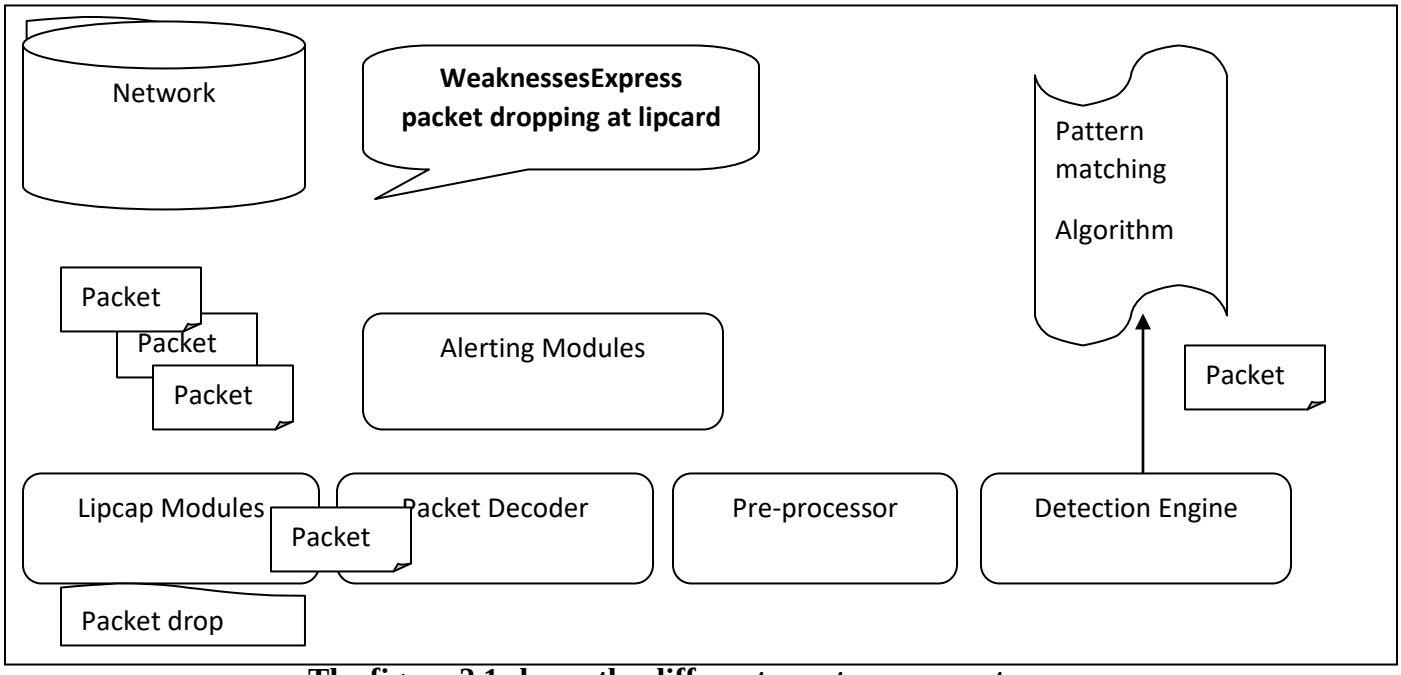
as a light weight intrusion detection system at that time snort used many different plug-in that are being used now. The latest version of snort tool came to being in 2003 snort 2.x.x.x has 75,000 line of code.

Snort Intrusion Detection System

According to Rani and Singh (2010) defined snort as a single threaded network security mechanism that work based on four difference configuration mode, Packet sniffer mode, packet logger mode, detection mode and prevention mode or inline mode. Snort is an open source network intrusion detection system which is configured in a network PC as a network IDS. Also, snort is incorporated in third party solutions, snort tool get wide acceptance by many industries all over the world with millions of a downloads. The detection of malicious traffic by snort is done by using transmission control protocol stack. A deep packet payload inspection is carried out by matching the observed packets and pre-defined snort signature. In a network, snort can be implemented in many different platforms such as Linux, FreeBSD, windows but snort has higher performance when deployed in a Linux platform because of its higher supportability, stability, security and reconfigurable network subsystems.Also, snort performance is optimized by using Berkeley filter (BPF) using BPF only interested network packet are allowed to pass for analyzes by the snort components (Terrence *et. al*, 2010).

Similarly, Snort packet logging performance and its fault alarm produces during packet inspections depends on the accuracy of its configurable components. i.e. snort packet grabbing mechanism (lipcap library). In addition the accuracy of how detection engines algorithms inspect the packet payload to detect malicious pattern gives rise to the snort better performance. Also, these components are separated into different dependent components; the first component is the packet capturing mechanism or modules through which the transmitted network is tossed in to the snort. After the lib-cap accomplished its functions the captured packet in raw form is passed

to the decoder components after the raw packet is being decoded or prepared for pre-processing its send in to the snort next components for pre-processing which is the pre-processor component. The pre-processor perform many task on the received packets before sending it to the detection engine, among the functions are packet examinations, manipulations, and defragmentation and packet classifications. The detection engine which is the main snort components perform a test to check whether the packet is malicious to detect intrusion and the result obtained is send to the final plug-in which is the snort output.



The figure 2.1 shows the different snort components

Pattern Matching Algorithms

Pattern matching algorithm according to (Yaron,2011) is a core component of intrusion detection which is composed of step by step instructions made to match the incoming packet string against the pre-defined signature with the aims of finding the malicious signature. Pattern

matching algorithm is a snort core component that plays a vital role in packet inspection for a malicious identification. The pattern matching algorithms according to (AbuHmed *et. al*, 2012) are classified according nature of the platform where they are deployed, that is software based algorithm or hardware based algorithm and in some cases pattern matching algorithms are usually found to have both characteristic software and hardware based as shown in figure 2.4 below.(Hong,2012) stated in his literature that in some case algorithm categories based on theie mode of operations and this categoration had leaded to the widely known pattern matching techniques types algorithms, single pattern matching and multiple pattern matching algorithms. In single pattern matching techniques, the algorithms scans the entire text and match one pattern at a time while in the multiple pattern matching many patterns are match at a scan. Indeed, the most commonly known types of pattern matching algorithms are either Ah-corasick, boyer-more or Wu-Manber algorithm (Weinsberg *et. al*,2011).Basically, as a result of many drawbacks or limitation of these algorithms researchers aimed at developing new algorithms based on the traditional normal behaviors of the existing algorithm to come up or solve the challenges of their predecessor in order to have good and efficient performance in packet inspection

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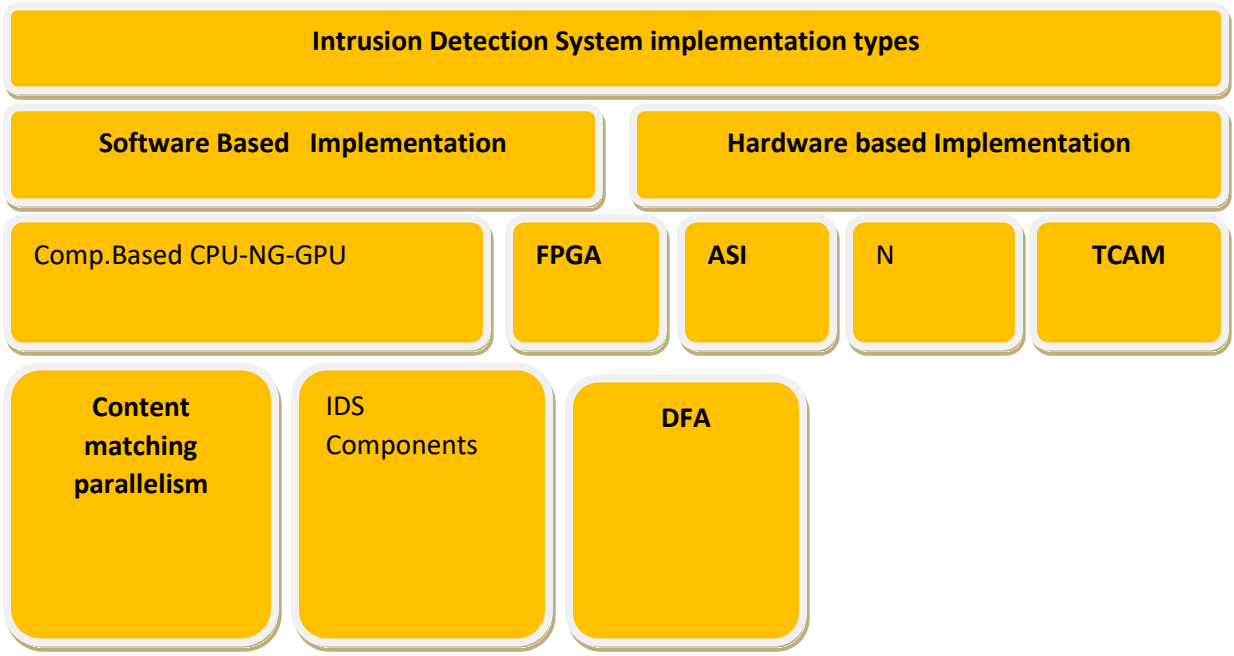

Figure 2.1 hardware and software based IDS implementation

In addition, among the modified or newly build algorithms includes quick search algorithm, hoorspol, dual, hybrid algorithms and many more among which are going to be described in the later section of this paper.

Despite the current enhancement or improvement often did to the snort pattern matching algorithm they are yet to meet the performance requirement needed for snort to function well in a higher traffic network. Many challenges are yet to be solved by the current traditional and modified pattern matching algorithm. Basically, pattern matching algorithms uses four different methods in performing pattern matching which includes left to right comparison, right to left comparison, specific order and un-relevant order.

Aho Corasick Algorithm

Aho-Corasick is a multi patterns matching algorithm, which is usually used for packet string matching in intrusion detection system. This is build often Automata technology it requires more or much time for performing pattern analysis and its considered effective in performing pattern search independent of pattern size. This algorithm contains difference time complication of search, this time is expresses as either 0 (n) or 0 (n x log @) depending on either the automaton is in direct 71 access table. Indeed, for the algorithm pre-processor components to perform its function it requires more time and this can be done up line depending on the application it dealt with. In the traditional Aho carosick algorithm building deterministic finite automaton can be achieved by using a single unit of character. Many problems hinders the performance of Aho Corasick pattern matching algorithm, (Norton,2004). Also based on the algorithm implementation a measurable improvement has been presented in terms of memory requirement reductions as highlighted in (Jonhson and Yao,2002), which had proposed a best possible

memory representation of the sparse state table, but this had contributed to the lost of performance compared to the full matrix presentation. Similarly, this algorithm is considered to be out-dated from being used as a snort algorithm quite long of time. Since addressing the memory requirement and the matching efficiency had became difficult issue to be addressed completely, the algorithm deals with forming of a finite state machine and the input text usually processed using pattern matching machine in a single pass. The example of such is given in:

Figure 2.4 below shows the construction of finite state machine using the four different key words

The state machine is constructed based on the go to function that allowed moving from one state to another.

Wu-Moore algorithm

Wu-Moore pattern matching algorithm is based on the Boyer Moore algorithm which has the capability to perform multiple searches in a single step. The Wu Moore because of its efficiency it allow more than one character to be matched at once, therefore, its pattern shift is made to be small this is because during text scan there is possibility for the algorithm to make match between two adjacent last characters of the patterns and text. Also, the WM algorithm make used of two distinct mechanisms while searching a text for a specific pattern, the two mechanisms includes, filter mechanism that is form based on the hash technology and other mechanism utilized by this algorithms is block character shift mechanism. This mechanism is a borrowed idea from the Boyer Moore bad character shift function the matching process in this algorithm is done by calculating the hash values of the suffix block character which is compared with that of the pattern value.Similarly, the main function of the bad character shift is to ensure the shifting of the windows when match occurs. Operationally, Wu-Moore algorithm (WM) has two main processing stages as done by other traditional pattern matching algorithms. The main stages

include pre-processing stage and pattern searching stage. In this operations are perform by the algorithm which includes setting the size of the matching windows as well as establishment of the three important functions i.e. Shift table, hash table and prefix table. Many matching information are stored in the functions such as shift distance, entry of the link list used for linking the pattern that are of the same or similar mach window in the text also another entry information of link list are stored that specified the group of pattern having similar prefix within the match window. For examples assuming a text donated by the letter *T= t1,…t2…..,tn''*, where letter n indicate the overall length of the text characters and the patter represented by letter P, the pattern set is given by *''P={p1….p2….,Pi}* , and the match window size is given by the letter ''m'' and the block character size is given by an expression *''B''=2''*

Knuth Marith Algorithm

The Knuth-Morris-Pratt (KMP) algorithm is an improved idea of Brute Force algorithm, which uses a shift function based on the notion of the prefixes of the pattern and it is measured as the first linear string matching algorithm. The algorithm is used by core component of intrusion detection system to detect signature pattern match in the incoming network packet with the aims of detecting an intrusions. The Algorithm is a single string matching algorithm unlike Boyer Moore algorithm, this algorithm work in a different way. The main concern of the KMP algorithm is to find occurrences of pattern "P" in string of text "T". However, in a operation by this algorithm two distinct operations or stages are carried out, firstly, each character of the pattern "P" is compared with the pre-defined set of string, if matched is found the operation is continuing, otherwise, the pattern is shift by a position toward right and the above mentioned procedure is repeated again. Indeed, the running time of the Knuth Marith algorithm (KMP) is express mathematically as o (m+n) where n and m represent the length of the pattern and string text respectively (Kumar,

2011).However, Knuth Marith algorithm in dealing with set of string data it adopts two phases, pre-processing phase and searching phase. The Knuth pattern matching algorithm is based on feature matching that is widely adopted in the modern intrusion detection, less time of o(n) is set to be achieved by ignoring the set of characters previously been compared and one important characteristic of Knuth Marith algorithm (KMP) backtracking never occurs. Similarly, Knuth uses prefix function to avoid backtracking (Unused shift of the pattern) and the Knuth Marith (KMP) matcher that returns the number of shifts of the pattern when a successful matched is done. However, work by Baker (2005), Good feature of KMP pattern matching algorithms has made it possible for most of the intrusion detection system to use it for packet pattern matching, the algorithms uses two difference mechanism single comparator and pre-computed transition table which enable reduction of repeated comparison. In addition, in pattern matching, computational efficiency is needed as such; the Knuth Marith algorithm (KMP) is made to be used as a hardware based pattern matching algorithm. The implementation guarantees a higher throughput in parallel hardware architecture.However, the snort performance degradation in intrusion detection is course as result of inefficiency of the detection engine to performs intrusion detection at the rate of the network speed (Soumya,2010) and the efficiency of snort detection engine depends on how accurate and fast its pattern matching algorithm could perform deep packet inspections,(Ibrahim,2011) comparing pre-defined signature pattern and that of the incoming network packet. Therefore, in this review many literatures are studied that have contributed in enhancing snort detection performance based on the platform where the tool (Ids) is configure and the pattern matching algorithm used.

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