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NetworkMonitoring System (NMS)

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Abstract: Due to rapid changes and consequent new threats to computer networks there is a need for the design of systems that enhance network security. These systems make network administrators fully aware of the potential vulnerability of their networks. This paperdesigns a Network Monitoring System (NMS) which is an active defense and complex network surveillance platform designed for ISPs to meet their most rigorous security requirements. This system is motivated by the great needof government agencies, ecommerce companies and Web development organizations to secure their computer networks. The proposed system is also used by network administrators to enable them understand the vulnerabilities affecting computer networks. This enables these administrators to improve network security. The proposed system is a lawful network traffic (Internet Service Provider IP trffic) interception system with the main task of obtaining network communications, giving access to intercepted traffic to lawful authorities for the purpose of data analysis and/or evidence. Such data generally consist of signaling, network management information, or the content of network communications. The intercepted IP traffic is gathered and analyzed for network vulnerability in real time. Then, the corresponding TCP/UDP traffic (Web page, email message, VOIP calls, DHCP traffic, files transferred over the LAN such as HTML files, images, and video files, etc.) is rebuilt and displayed. Based on the results of the analysis of the rebuilt TCP/UDP an alarm could be generatedif amalicious behavior is detected. Experimental results show that the proposed system has many features that make it much better than existing similar tools such as wireshark. In addition, experimental results show that the proposed system has high accuracy and efficiency in regards to network packets capturing and corresponding Web pages restructuring.

Index Terms—Network security, nework traffic interception, packet filtering, network malicious behavior, network attacks

I.

INTRODUCTION

Internet users are at high risk of virtual attacks. At the early history of the Internet only speacialist used it. Today, the Internet has already become an essential part of our lives. It's where we access our banking records, credit card statements, tax returns and other highly sensitive personal information. By the end of this decade, over 2 billion people will be connected to the Internet that's about one third of the world's current population [1].

Due to the openness of the Internet it opens the door to serious, potentially devastating threats. Unlike corporate and government computer systems, few personal computers have any safeguards beyond basic virus protection. That means anytime you're online, you are a potential target for online criminals and hackers [2].

Computer networksmalicious activities usually affect computers that are connected to the Internet, because these connections are attractive targets for attackers. Symantec categorizes malicious activities as follows:

- A. Malicious code: This includes programs such as viruses, worms, and Trojans that are secretly inserted into programs. The purpose of malicious code includes destroying data, running destructive or intrusive programs, stealing sensitive information, and compromising the security or integrity of a victim's computer data [3].
- *B.* Spam zombies: These are remotely controlled, compromised systems specifically designed to send out large volumes of junk or unsolicited email messages. These email messages can be used to deliver malicious code and phishing attempts [4].
- *C.* Phishing hosts: Phishing hosts are computers that provide website services in order to illegally gather sensitive user information while pretending that the attempt is from a trusted, well known organization by presenting a website designed to mimic the site of a legitimate business [5].
- *D*. Bot-infected computers: Malicious programs have been used to compromise computers to allow an attacker to control the targeted system remotely. Typically, a remote attacker controls a large number of compromised computers over a single reliable channel in a botnet, which can then be used to launch coordinated attacks [6].
- *E.* Network attack origins: These measure the originating sources of attacks from the Internet. For example, attacks can target SQL protocols or buffer overflow vulnerabilities [7].
- *F.* Web-based attack origins: These measure attack sources that are delivered via the Web or through HTTP. Typically, legitimate websites are compromised and used to attack unsuspecting visitors [8].



In adition, spyware is the new threat antivirus software won't find. Internet criminals create spyware to steal sensitive personal information. Stopping spyware requires even greater protection [9].

One of the most popular LAN attacks is session hijacking. Session hijacking is also referred to as TCP session hijacking, a security attack on a user session over a protected network. The most common method of session hijacking is called IP spoofing, when an attacker uses source-routed IP packets to insert commands into an active communication between two nodes on a network and disguising itself as one of the authenticated users [10]. In IP spoofing, the used IP address indicates that the message is coming from a trusted host [11].

Another type of session hijacking is known as a man-in-the-middle attack, where the attacker, using a sniffer, can observe the communication between devices and collect the data that is transmitted. In a man in the middle attack, the intruder uses a program that appears to be the server to the client and appears to be the client to the server. The attack may be used simply to gain access to the message, or enable the attacker to modify the message before retransmitting it [12].

This paper proposes a new networkpacket forensics system that monitors and intercepts network traffic crossing Network Interface Cards (NICs). It works by sniffing all the packets that arrive throw the NIC and recording them in log files, supporting packet filtering and file recovery of the sniffed packets. It applies multiple policies to operate simultaneously on the entire nonitored IP packet stream. This means that while network managers/governmental agents search for different strings inside each IP packet, they can also intercept VoIP calls, extract dialed digits and correlate DHCP log-ins with IP addresses. Each policy can have different resulting actions, such as forwarding packets to another analysis system or generating security threat reports. The proposed system is called aNetwork Monitoring System (NMS). It has the following capabilities:

- G. Building an ISP Internet traffic monitoring / network behavior recording components
- H. Logging IP traffic
- I. Building lawful IP packet interception tool
- J. Restoring the files transferred over the LAN (HTML files, images, videos, ...) using corresponding IP packets.

The motivation of this paper is that ISPssufferfrom the lack of the tools support low level packet sniffing and monitoring. In addition, most of the present tools do not have the ability restore the original files from the intercepted packets. Also, current similar tools are very expensive.

The rest of the paper is organized as follows: Section two presents related work. Section three presents the detailed design of the NMS. Section four presents experimental results. Finally, section six concludes the paper.

II. RELATED WORK

This section presents some of the tools in the literature that are similar to the proposed NMS, namely; Wireshark, SkyGrabber, Free Network Analyzer, and NetworkMiner Analysis Tool.

Wireshark is a network packet analyzer that captures network packets and displaystheir data as detailed as possible. A network packet analyzer is a measuring device used to examine what's going on inside a network cable. Wireshark is perhaps one of the best open source packet analyzers available today [13].Some examples of users of Wireshark include:

- A. Network administrators use it to troubleshoot network problems
- B. Network security engineers use it to examine security problems
- C. Developers use it to debug protocol implementations
- *D.* People use it to learn network protocol internals

Some of the features Wireshark provides: available for UNIX and Windows, capture live packet data from a network interface, open files containing packet data captured with tcpdump /WinDump, Wireshark, and a number of other packet capture programs, import packets from text files containing hex dumps of packet data, display packets with very detailed protocol information, save packet data captured, export some or all packets in a number of capture file formats, filter packets on many criteria, search for packets on many criteria, colorize packet display based on filters, create various statistics [14, 15].

SkyGrabber is an offline satellite Internet downloader.It allows to accept satellite Internet data, assemble this at in files (avi,mp3,mp4,etc.) and save files onto hard disk [16]. The program has user-friendly interface, diverse filter system and satellite provider manager inside.SkyGrabber works only with free-to-air satellite Internet data. Features **of**SkyGrabber include [16]:

- *E.* ssemble TCP/IP sessions in files
- F. Lock frequency to accept satellite Internet data
- G. Support DiceqC (uncommitted/committed)
- H. Satellite provider manager



- *I.* Filter manager by file type
- J. Filter manager by IP addresses (MAC addresses)
- K. Monitoring system resource information (CPU usage, Memory usage, Free disk space)
- L. Monitoring satellite signal information (Level, Quality)
- M. Displaying progress bar of downloaded files

Free Network Analyzer is a software network packet sniffer and protocol analyzer for Windows platform. Using this free network monitoring software you may intercept any data transmitted via wired broadcast or wireless LAN (WLAN) and Internet connections of computers. Network sniffer allows users to capture, filter and display any traffic data flowing through network adapters. It decodes captured network communication packet's raw data, displaying the binary, hex, decimal and text field values in each packet, and analyzes its contents according to the RFC and other specifications. Packets data is parsed, extracted and represented in simple human-readable form, allowing users to perform effective forensic analysis of any data transferred via PC network interfaces.Free network protocol analyzer installs NDIS filter driver over the network adapter device driver and then monitors all requests passed via Windows network interface.This free network data explorer supports advanced data filtering, highlighting and searching for patterns with regular expressions, which makes this software extremely useful for deep network traffic analysis [17].

Finally, NetworkMiner is a Network Forensic Analysis Tool (NFAT) for Windows (but also works in Linux / Mac OS X / FreeBSD). NetworkMiner can be used as a passive network sniffer/packet capturing tool in order to detect operating systems, sessions, hostnames, open ports etc. without putting any traffic on the network. NetworkMiner can also parse PCAP files for off-line analysis and to regenerate/reassemble transmitted files and certificates *from* PCAP files. NetworkMiner makes it easy to perform advanced Network Traffic Analysis (NTA) by providing extracted artifacts in an intuitive user interface. The way data is presented not only makes the analysis simpler, it also saves valuable time for the analyst or forensic investigator. NetworkMiner has, since the first release in 2007, become a popular tool among incident response teams as well as law enforcement. NetworkMiner is today used by companies and organizations all over the world.[18].

III. NETWORK MONITORING SYSTEM (NMS)DESIGN

A. Introduction

NMS is a network packet analyzer that captures network packets. Packet data is then parsed, extracted and represented in simple human-readable form, allowing users to perform effective forensic analysis of any data transferred via PC network interfaces. Then, corresponding packet data is displayed for the user to examine.

The following software packages and tools are required to be able to use the designed tool:

- 1) Visual studio 2012
- 2) SQL server 2008
- *3)* Server with windows serves 2012

NMS can work in situations with NIC that receive high traffic. NMS has many capabilities and features including the following:

- 4) Capture live packet data from a network interface.
- 5) Display packets with very detailed protocol information.
- 6) Support both wired an wireless LAN interfaces
- 7) Support many types of packet filters (source, destination, protocol type, packet direction, ...)
- 8) HTTP analysis (extract the HTTP data from the packets (method, ULR, file name, content type, compression type))
- 9) Support filters on HTTP data (HTTP methods, content type, HTTP response, user IP, Host website, content size)
- 10) Generate files from packets (Generateone file, Generate all files by user, Generate all files by host)
- 11) Support high traffic data because of the good memory management

B. Proposed System Modules

NMS consists of six modules and three queuesas shown in Fig.1.



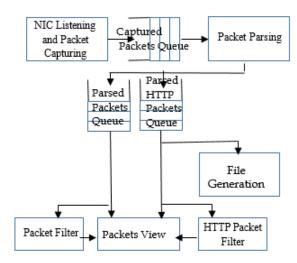


Fig.1 NMSblock diagram

As Fig. 1 shows, NIC Listening and Packet Capturing module listens to Network Interface Card (NIC)and captures crossing packets. These captured packets are put into Captured PacketsQueue. Captured packets are then parsed by the Packet Parsing module and two separate queues are generated: Parsed HTTP Packets Queue (for HTTP packets only) and Parsed Packets Queue (for all packet types). Hence, the proposed system treats HTTP packets separately. Either the Parsed Packets Queue or the Parsed HTTPPackets Queueis used by the File Generation module to generate the corresponding files that the packets represent. We could apply HTTP Packet Filter to Parsed HTTPPackets Queue and Packet Filter to Parsed Packets queue to the user in the packets view pane in themain window of NMS.

NMS is a multithreaded parallel system where all modules run simultaneously. Sepecifically, the following modules run in parallel as parallel threads:

In the following sub-sections, we describe the modules and queues shown in Fig. 1 in some detail.

1) NIC Listening and Packet Capturing Module : NIC Listening and Packet Capturing moduleselects the network interface to listen to, and creates a thread to start listening to it. When a packet is transmitted or received, the thread copies the packet and pushes it to the captured packets queue. This queue is a mutual exclusion data structure because the NMS is a multithreaded system where other modules need to read/write the queue. The NIC Listening and Packet Capturing modulepseudo-code is shown in Code Fragment 1.

> Identify and select a network interface that is connected to the compute running the module to start monitoring. Create a listening thread Check the listening status Start listening to the selected NIC Add received packets to the Captured Packets Queue

Code Fragment 1 The NIC Listening and Packet Capturing module pseudo-code

Fig.2 shows the block diagram of the NIC Listening and Packet Capturing module and the data flow within the module. The module starts by identifying the NICs connected to the computer running the module. The user needs to select one of these NICs for monitoring. Then, a thread is created to listen to the packets crossing the selected NIC. Then, packets are captured and added to the Captured Packets Queue.



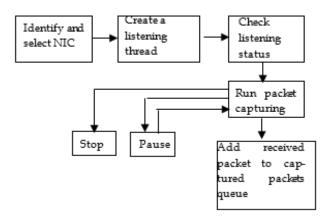


Fig.2 NIC Listening and Packet Capturing moduleblock diagram

- 2) Captured Packets Queue: Captured Packets Queue is a data structure that is used to store the packets that are captured by the NIC Listening and Packet Capturing module. This is a temporary storage for packets that are captured but not parsed yet. Since NMS is multithreaded, this queue is a mutual exclusion access storage to prevent packets being accessed by more than one thread simultaneously.
- 3) Packet Parsing Module: The Packet Parsingmodule (see Fig. 3) is a thread that reads packets from Captured Packets Queueand analyses them, i.e., parses their fields to study their details. Itextracts the IP packet header, TCP/UDP header, and HTTP header.It builds a data structure for each packet that contains the parsed fields. Then, it addsparsed packets to Parsed PacketsQueue. If the parsed packet is an HTTP packet, then this module adds it to Parsed HTTP Packets Queue.

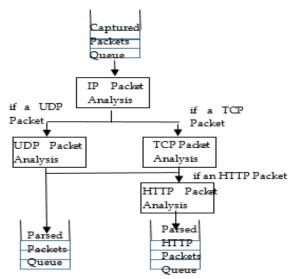


Fig. 3Packet parsing module

The pseudo-code of the Packet Parsing module is shown in Code Fragment 2.

Create a parsing thread While Captured Packets Queue is not empty Dequeue a packet from the queue Apply IP header analysis Check transfer protocol If the protocol is TCP 2.4.1 apply TCP header analysis 2.4.2 If protocol is HTTP (port 80 or 8080)



Apply HTTP header analysis	
Add packet to the Parsed HTTP Packets Queue	
5 If the protocol is UTP	
apply UTP header analysis	
Add packet to Parsed Packets Queue	
End while	

Code Fragment 2 Packet Parsing module pseudo-code

IP packet analysis module includes parsing the fields (these fields are added to the built data structure) in the IP header of the packet which are shown in Table 1.

TADLE IF ARSED FIELDS IN THE IF HEADER		
Field	Meaning	
VersionAndHeaderLength	8 bits for version and header length	
DifferentiatedServices	8 bits for differentiated services	
	(TOS)	
TotalLength	16 bits for total length of the header	
	& message	
Identification	16 bits for identification	
FlagsAndOffset	16 bits for flags and fragmentation	
	offset	
TTL	8 bits for Time To Live (TTL)	
Protocol	8 bits for the underlying protocol	
Checksum	16 bits containing the checksum of	
	the header (checksum can be nega-	
	tive so taken as short)	
SourceIPAddress	32 bit source IP Address	
DestinationIPAddress	32 bit destination IP Address	
Direction	one bit direction of the packet	
Data	the data transmitted with the packet	

TABLE 1PARSED	FIELDS IN	THE IP	HEADER
	I ILLUD III	11111111	THEFT

TCP packet analysis task includes parsing the fields (these fields are added to the built data structure) in the TCP header of the packet which are shown in Table 2.

Field	Meaning
SourcePort	16 bit for the source port number
DestinationPort	16 bits for the destination port number
SequenceNumber	32 bits for the sequence number
AcknowledgementNumber	32 bits for the acknowledgement number
DataOffsetAndFlags	16 bits for flags and data offset
Window	16 bits for the window size
HeaderLength	Header length
MessageLength	Length of the data being carried
TCPData	array of bytes as data carried by the TCP
	packet

UDP packet analysis task includes parsing the fields (these fields are added to the built data structure) in the UDP header of the



packet which are shown in Table 3.

TABLE STARSED TILLDS IN THE ODT TILLDER		
Field	Meaning	
SourcePort	16 bits for the source port number	
DestinationPort	16 bits for the destination port number	
Length	Length of the UDP header	
Checksum	16 bits for the checksum (checksum can be negative so taken as short)	
UDPData	array of bytes as data carried by the UDP	

TABLE 3PARSED FIELDS IN THE UDP HEADER

HTTP packet analysis task includes parsing the fields (these fields are added to the built data structure) in the HTTP header of the packet which are shown in Table 4.

TABLE 4 I	ARSED FIELDS IN THE HITP HEADER		
The request data			
RequestPack-	index of the packet at all received		
etIndex packet list			
Req_HTTPMe	Requests a web application override		
thod	the method specified in the request		
Req_Required	The requested URL		
URL			
Req_HTTPVer	Used HTTP Version		
sion			
Req_Host	The domain name of the server		
Req_UserAge	The user agent string of the user agent		
nt			
Req_Accept	Content-Types that are acceptable for		
	the response		
Req_AcceptLa	List of acceptable human languages for		
nguage response			
Req_AcceptEn List of acceptable encodings			
coding			
Req_Cookie	An HTTP cookie previously sent by		
	the server		
Req_Connecti	Control options for the current connec-		
on	tion and list of hop-by-hop request		
	fields		
Req_Pragma	Implementation-specific fields that		
	may have various effects anywhere		
	along the request-response chain		
Req_CacheCo	Tells all caching mechanisms from		
ntrol	server to client whether they may		
	cache this object		
The response data			
Response-	index of the packet at all received		
PacketIndex	packet list		
Res_StatusCo	CGI header field specifying the status		
de	of the HTTP response		

TABLE 4 PARSED FIELDS IN THE HTTP HEADER



Res_Date	Acceptable version in time		
Res_Server	A name for the server		
Res_LastModi	The last modified date for the re-		
fied	quested object		
Res_ETag	An identifier for a specific version of a		
	resource		
Res_AcceptRa	What partial content range types this		
nges	server supports		
Res_Connecti	Control options for the current connec-		
on	tion and list of hop-by-hop request		
	fields		
Res_ContentT	The MIME type of the body of the		
ype	request (used with POST and PUT		
	requests)		
Res_ContentE	The type of encoding used on the data		
ncoding			
Res_ContentL	The length of the request body in oc-		
ength	tets (8-bit bytes)		

- 4) Parsed PacketsQueue : Parsed Packets Queue is a data structure that is used to store the parsed packets. Only the Packet Parsing module writes to this queue. The following modules read from this queue: Packet Filter module reads the queue to select the packets from the queue that meet some requirements i.e., meet the packet filter parameters. The File Generation module reads the queue in order to build the corresponding files that packets represent. Since the proposed tool is multithreaded, this queue is a mutual exclusion access storage to prevent packets being accessed by more than one thread simultaneously.
- 5) *Packet FilterModule*: Packet Filter module gets the packets filter parameters from a GUI form (see Fig. 4). Then, it filters the Parsed Packets Queue based on these parameters. These parameters are entered by the user. As shown in Fig. 4, the currently allowed filter parameters are:
- a) Source IP
- b) Destination IP (target IP)
- c) Source port
- d) Destination port (target port)
- *e)* The transport/application protocol e.g., TCP, UDP, DNS, HTTP, HTTPS
- *f*) The direction of the packet (upload, download)

-	FilterForm		
			Protocols
Source IP		Source Port	
Target IP		Target Port	HTTP
Direction	~		DNS
	🔽 Filter 🏑	Clear Close	

Fig. 4 Packet Filter module packets parameters form

When the user selects the packets filter parameters and clicks "Filter" on the form in Fig. 4, the module filters all parsed packets based on the selected parameters. Packets View module uses output of Packet Filter module to display packets.

6) Parsed HTTP Packets Queue : Parsed HTTP Packet Queue storesparsed HTTP packets. This queue iswritten by the Packet Parsing module when the module parses HTTP packets and read by the Packets View module to display packets. The queue is also read by HTTP Packet Filter module. The queue stores both the request parameters and response parameters for any HTTP communication. This enables NMS in the analysis of HTTP content and FileGeneration module in generating corresponding



HTML files.

- 7) *HTTP Packet Filter Module:* HTTP Packet Filter module gets the packets filter parameters from a GUI HTTP Packets Filter form (see Fig. 5). Then, it filters the Parsed HTTP Packets Queue based on these parameters. These parameters are entered by the user. As shown in Fig. 5, the currently allowed filter parameters are:
- 1) User IP address
- 2) Host (Web site name i.e., the domain name)
- *3)* Content size (Greater than/Less than)
- 4) HTTP methods (GET, POST, HEAD, PUT, ...)
- 5) Content type (HTML, PHP, CSS, JS, GIF, JPG, PNG, ICO, ...)
- 6) HTTP Response (SUCCESSFUL, REDIRECTION, CLIENT ERROR, SERVER ERROR)

			HTTP Methods	Content Type	HTTP Response
User IP			GET	HTML	SUCCESSFUL 2XX
			POST	PHP	□ REDIRECTION 3XX
Host			HEAD	CSS	CLIENT ERROR 4XX
			D PUT	🗆 JS	SERVER ERROR 5XX
Content Size			DELETE	GIF	1
Jonteni Size	Greater Tha v		OPTIONS	□ JPG	
			CONNECT	□ PNG	
			TRACE	🗆 ICO	
		Filter	Clear	Close	
		Fitter	Clear	Close	

Fig. 5 HTTP Packet Filter module form

When the user selects the HTTP packets filter parameters and clicks "Filter" on the form in Fig. 5, the module filters all parsed HTTP packets based on the selected parameters. PacketsView module uses the output of HTTP Packet Filter module to display packets.

7) *Packets View Module:* PacketsView module displays packets in the packets view pane in the main window of NMS. Type of packets displayed is based on some options selected by the user as shown in Code Fragment 3.

If (Packet Filter not selected AND HTTP Packet Filter not
selected)
Display packets in Parsed Packets Queue
If (Packet Filter selected latest)
Display packets in Parsed Packets Queue after applying
selected Packet Filter parameters
If (HTTP Packet Filter selected latest)
Display packets in Parsed HTTP Packets Queue after
applying selected HTTP Packet Filter parameters

Code Fragment 3 Selection creteria used by Packets View module to display packets

When Packet Filter module parameters or HTTP Packet Filtermodule parameters are updated, then Packets View module updates the packet view pane to display packets that meet the new parameters.

- 8) File Generation Module: File Generation module currently supports reconstructing HTTP files. It builds files from their corresponding HTTP packets. This module getsits input from Parsed HTTP PacketsQueue and produces the generated file(s) as an output. The module reads all related packets that constitute the file(s) to be built and sortsthem according to theirHTTP sequence number and combinestheir data in binary format and stores this data in a newly created file. Hence, this module restores the original files from their constituting packets.
- a) The module supports three modes:
- *i*) The selected file mode: A single file is generated which is the file that contains the selected packet.



- *ii)* The selected host mode: All files that are transmitted by the host which transferred the selected packet are generated.
- *iii)* The selected user mode: All files that are transmitted by the user which transferred the selected packet are generated.

The pseudo-code of the File Generation module for the selected file mode is shown in Code Fragment 4. It generates a single file.

//User selected "selected file mode"
Select a packetp from the packets view pane
List L = select all packets in the Parsed HTTP Packets
Queue for which AcknowledgementNumber≥ Acknow-
ledgementNumber of p
Sort L by SequenceNumber
FILE $f = CreateFile()$
Open the file f
Save f at the specified path by the user
Use data in p to specify file name and extension of f
For each packet pxin L
Extract data from px (in bytes)
Write extracted data to f
If PSH flag of p isset //this is the last packet
close f
Go to 10
Close f
If ContentEncoding of $f = gzip // file$ is encrypted
decompress f
. End

Code Fragment 4 File Generation module pseudo-code for the selected file mode

The pseudo-code of the File Generation module for the selected host mode is shown in Code Fragment 5. It generates multiple files.

//User selected "selected host mode"
Select a packet p from the packets view pane
h = host name (server name) in packet p
List $L =$ select all packets in the Parsed HTTP Packets
Queue for which host name $=$ h
Build all files that packets in L represent using code
similar to Code Fragment 4.
Save all files at the specified path by the user
End

Code Fragment 5File Generation module pseudo-code for the selected host mode

The pseudo-code of the File Generation module for the selected user mode is shown in Code Fragment 6. It generates multiple files.

//User selected "selected user mode"
Select a packet p from the packets view pane
u = user (client) in packet p
List L = select all packets in the Parsed HTTP Packets
Queue for which user name $=$ u
Build all files that packets in L represent using code
similar to Code Fragment 4.
Save all files at the specified path by the user
End

Code Fragment 6File Generation module pseudo-code for the selected user mode



IV. EXPERIMENTAL RESULTS

This section validates NMS therough experimentation. It examinsNMSthrough executing it and shows itsactual behavior when it is running. We verify that it runs correctly and efficiently.

Fig. 6 shows the main window of NMSwhen it is launched. The main window consists of five components (They are numbered in the figure):

- A. Combo and Toolbar:CombodDetects the NICs connected to the computer. The toolbar displays 4 tool icons. These buttons are start/stop button to start/stop capturing packets, filter button to filter displayed packets, HTTP filter button to filter displayed HTTP packets, and clear button to clear the packet view pane.
- *B.* Packetsview pane: Displays parsed packets (after applying filters). The top line of the pane displays the header (title of each displayed field of the packet)
- C. Data: Displays data of the selected packet
- D. Hexadecimal: Displays hexadecimal value of data of the selected packet
- E. Packet details: Displays details of the selected packet

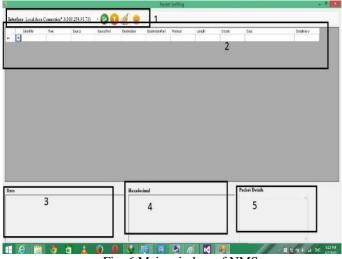
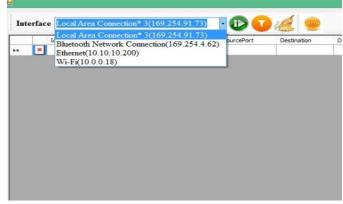


Fig. 6 Main window of NMS

Fig. 7 shows the NIC selection combo box which lists all NICsconnected to thecomputer thatruns NMS. In addition, the NIC selection combo also shows the corresponding IP addresses of these NICs. Selecting the NICto be monitored is the first step that has to be done before start listening to the the rossing packets and capturing them. After choosing the interface, the user has to press the "start" button which is shown in the main window of NMS (the green button in the toolbar).

After pressing the "start" button in the main window of NMS, the list of crossing packets will be parsed and displayed in the packets view pane (See Fig. 8). In addition, these captured packets will be added to the Captured Packet Queue.

The Packet Parsing module adds captured packets after being parsed to the Parsed Packets Queue and the adds the parsed HTTP packet to the Parsed HTTP Packets Queue.







_												_
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1	10145	2015-09-07 Mit		39622	137.56.141.118	40)	10795	30	Yet Pv4(Dff.,	y ¹¹ - y Chatthe BOyge	10 10 10 10 10	
ŧ	5250	2015-08-07 18	5.329.135.107	23675	10.0.18	38415	UDP	321	Yet P (4) Dff	sect-ut 401/15 stimetra	8F A4 62 F9 1	
1	2000	2015-08-07 88	35.0.0.18	39435	5.109.135.107	23673	1,0P	209	Ven P v4 Dff	1"\$()\$0 386.405 \$1.40~	83 99 A7 A3	
ŧ	1237	2015-08-07 18	352, 168, 1, 1		224.0.0.1		124	28	Ver: P v4 Diff			
ş	29280	2015409-07 88	45.52.100.29	46	10.0.2.38	38536	HTP5	147	Ver IP #4 [Dff.,	411 - +11 x10'6/J+5J4/J	14 03 03 00 0	
t	13466	301548-07 88	10.0.0.18	59535	65.52.108.29	443	HTTPS	251	Yet: P v4) Dif	III a september and the	L7 03 03 00 D	
t	13467	2015-68-67 BR	30.0.0.18	39528	65.52.308.29	(1)	HTPS	1492	Ver: IP v4 (Dff	(Haw Decision and the second second	17 03 03 0E 5	
ł	28231	3015404-07.88	65.52 100.29	40	10.0.0.18	38536	INTER	12	Yet P #10/			
t	33348	2015-08-07 Rt	30.0.0.18	38415	77.98.234.45	33846	1,07	73	Ver: P v4 Dff	1.112 lo 1 w.85 star	EB 2E GA E1 6	
t	11427	2015-08-07 18	81.0.0.02	30415	94.22.55.122	59172	UDP	73	Vet IP v4 (DI)	96+12 ⁺¹ WVSS 51AU-10	0E 10 A0 07 8	
t	2511	2013-60-07 Million	30.0.0.18	39435	48.85.3.32	26541	UDP	73	¥e: P ≠ Dff	milleril i wats side-4	AC 81 10 79 8	
ŧ	181%	2015-08-07 18	78.2041.31	28090	10.0.0.18	36415	U0P	95	Ver: IP v4 Diff	ts carbo invalis ship-	87 35 Až FF 9	
1	30495	2015-09-07 88	30.0.0.18	39415	78-204.1.31	28080	U.OP	25)	Ven P v4 Dff	lookhis at this to	00 00 04 07 3	
ş	11307	211548-07 18	157, 56, 141, 114	46	10.0.5.10	26527	HTH	th	Yet: P v4 Dff	111 +11 P(\$p(s))906(++1),-2.	14 00 03 00 0	
t	1014	2015-08-07 88	20.0.1	39527	197.36.141.114	412	KITPS	39	ten P v41Dff	(III INITIATION CALIFICATION IN A STATEMENT AND A STATEMENT AN	L7 03 01 00 F	
		$ \begin{array}{cccccccccccccccccccccccccccccccccccc$										
iti.												

Fig.8Display of captured packets in thepackets view pane

When the user selectsapacket from the displayed packets in the packets view pane by clicking the left button of the mouse on it, the details of that packet are displayed as shown in Fig.9. Selected Packet details are displayed in the data, hexadecimal, and packet details panes which are located at the bottom of the main window of NMS.

Data about the selected packet (e.g., protocol, date, content-type, etc.,) are displayed in the data pane as shown in Fig. 10.

Data in hexadecimal format of the selected packet are displayed in the hexadecimal pane as shown in Fig. 11.

Packet details (IP packet details) of the selected packet are displayed in the packet details paneas shown in Fig.12.

Fig. 13 shows the tool tip of the packet when the mouse is positioned over the data field of that packet in the packets view pane.

When the user presses Filter button, he gets the form shown in Fig. 14. The figure displays the packet filter options supported by the application. Using this form, the user can select one of the options offered. After selecting the required options, the user can click "Filter" to display captured and parsed packets in the packets view pane that meet the selected filter options. The user can clear the selected options and start selecting new options again. He can also close the form without taking any action.

								Pack	et Sniff	ng								- 6 - 1
Int	erfa	ee Wi-Fi(10	0.0.18)		.00	14												
-	T	téritfar	Time	Source	SourcePort.	Destruction	-	DestrutePort	Polic	ai .	Leng	\$1	Detail	h .	Data		Detellinery	-
	4	27638	2015-08-07 18	162.155.252.143	80	30.0.0.38		39367	HTTP		2452		Ver 3	Pu4 Dff	+(ENV	. وفاة طنن (45 78 92 45 8	
	1	27629	2015-08-07 18	162.159.252.140	80	30.0.0.18		39567	HTP		382		Ver: B	Put Diff	. Re-turning - all	10-200.Ju.	C1 # 80 96 1_	
	4	61731	2015-08-07 18:	162.159.252.145	80	30.0.0.38		39368	HITP		1452		Ver: 5	P=4)Dff	HTTP/1.1 200 OK2 ale: Pro	07 Aug 2	48 54 54 50 2	
	1	24056	2015-08-07 18	10.0.0.18	39568	162.195.252	141	80	HTTP		-90		Ven B	Pv4(Dff	La			
	4	61732	2015-08-07 1B	162.159.252.140	80	10.0.0.18		39568	HITP		1452		Ver: P	Pv41DH		(\$16]E	AD 95 EE 9F 1_	
	4	61733	2015-08-07 18	152, 159, 252, 143	80	30.0.0.38		39368	HITP		822		Ver: D	Fv4[Diff	antel-joptatell-jo		ED 07 42 54 A	
	1	27475	2015-08-07 18	10.0.0.18	19576	362,191,295	141	80	HTTP		-40		Var S	Py4)Dff	lue .			
	4	47627	2015-08-07 18	162.159.255.140	80	25.0.0.18		39576	HETP		2452		Ver: B	Pution	OL. ART-I-STINIA	المالي الم	6F 45 FF 00 4_	
	1	47608	2015-08-07 1h	162.159.255.140	80	30.0.0.18		29526	HTP		1457		Ver I	Pution	. ITT_11	Relin	IF 88 54 54 5	
	1	35224	2015-08-07 18	216.137.AL.122	443	38.0.0.38		31506	HTTPS		52		Ver.3	P+4 0#				
	4	\$2755	2015-08-07 18	216.137.6L.122	443	80.0.0.86		39585	HITPS		52		Ver: F		ligi l			
	1	8738	2015-08-07 18	10.0.0	60097	20.00.138		23	(me		70		Ver: 2	Fuel (Caff	Le Lorad		01 00 01 40 0	
	4	36376	2015-08-07 18:	162, 159, 255, 143	80	30.0.0.18		39580	HITP		1452		Hart B	Petion	HTTP/L1280 CACHER FA		48 54 54 50 2	
	1	27476	2015-08-07 18	\$2.0.0.58	39580	742.159.255	.143	80	HITP		-40		Ver: F	Pu41Diff	los -	HTTP/1.1.		100
	4	36377	2015-08-07 IB	152 159 255 140	80	10.0.0.18		39580	HTTP		1452		Ver 2	P+4(Dff	3.org/1999/02/22+df-synt	Date Fri, 0 Contant-T	17 Aug 2015 10:27.22 Vpc: image/of	GMT
	4	36378	2015-08-07 18	362, 159, 255, 143	80.	30.0.0.18		39580	HTTP		1453		Ver: 3	Pu4 Dff	0x/usect_2#.###***	Content-L	ength: IEIEE1	
	1	274/7	2015-08-07 18	10.0.0.18	39580	342.139.255	10	80	HTP		-90		Heri 2	Fy4(Dff	Lug.	Connection Last-Minde	rt keep-alive Ked: This 05 Aug 20	11 20 12 10 10
	4	31379	2015-08-07 18	162.159.255.145	80	30.0.0.18		39580	HTP		3452		Ver: F	Pv410#	MnD*1.08642-0-1+0.0	TTom fee	1.45. 18777	
	4	36380	2015-08-07 18	162.159.255.140	80	90.0.0.18		39580	HTP		1452		Ver: 2	Pu4(Diff		Expires: Sa	4, 06 Aug 2016 YB27 ntrob public	22 GMT
	1	24965	2015-08-07 18	10.0.0.18	39568	362.199.252	143	80	HTTP		764		Vie: 3	Pv4 D#				-
at						Heza	decin	al							Packet Details			
All the second s	FILS STATE S	00 OK 7 Aug 2015 18:27 pe: mage/gf spftr 83801 famp-alive dt Thu, 06 Aug 2 k50a-94777 1, 06 Aug 2016 18 roll public, max-se fattas: HET 2-benefate	935 20:52:58 GMT			48 30 65 20 31 4D 74 61	54 30 3A 41 30 54 2D 67	54 50 20 4F 20 46 75 67 3A 32 0D 0A 54 79 65 2F	4B (72 (20) 37) 43 (70)	31 21 0D 02 69 20 32 30 3A 32 6F 63 65 32 69 60	44 20 33 23 2 32 32 32 32 32 32 32 32 32 32 3	61 30 35 20 65 69	32 74 37 20 47 68 60 43	< III >	P Detait	18		
1	1	ê 📋	1 🧿 🕯	۵ 🛓	0 0	9	R	0	2	P	1	-	ø		11	• 4 1	the of the	6 9.25 PM 8/7/2015

Fig.9Packet selection and its details display



Data

Data	
HTTP/1.1 200 OK	~
Date: Fri, 07 Aug 2015 18:27:22 GMT	
Content-Type: image/gif	
Content-Length: 83831	
Connection: keep-alive	
Last-Modified: Thu, 06 Aug 2015 20:52:58 GMT	
ETag: "55c3c92a-14777"	
Expires: Sat, 06 Aug 2016 18:27:22 GMT	
Cache-Control: public, max-age=31536000	
CF-Cache-Status: HIT	
Vary: Accent-Encoding	*

Fig.10Display of data of the selected packet in data pane

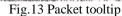
30	30	20	4F	4B	0D	0A	44	61	74	^
65	3A	20	46	72	69	2C	20	30	37	
20	41	75	67	20	32	30	31	35	20	
31	38	3A	32	37	3A	32	32	20	47	
4D	54	0D	0A	43	6F	6E	74	65	6E	
74	2D	54	79	70	65	3A	20	69	6D	
61	67	65	2F	67	69	66	0D	0A	43	
6F	6F	74	65	6F	74	20	40	65	6F	~

Fig.11Display of data (in hexadecimal format) of the selected packet in hexadecimal pane

IP Detials	^
Version = IP v4	
Source Address = 162.159.255.143	
Destination Address = 10.0.0.18	
Direction = Download	
TTL=55	
Flags= Don't fragment	
Checksum= 0x3f3	
Differentiated Services = 0x00 (0)	
Header Length = 20	
	~

Fig.12Display of details of the selected packet in packet details pane

Ver: IP v4 Diff				
Ver: IP v4 Diff				
Ver: IP v4 Diff	4www+	poogle-ana	01 00 01 00 0	
Ver: IP v4 Diff	HTTP/1.1 200 OKDate: Fri,	07 Aug 2	48 54 54 50 2	
Ver: IP v4 Diff		HTTP/1.1 2		
Ver: IP v4 Diff	3.org/1999/02/22-rdf-synt	Date: Fri, 07 Content-Ty	Aug 2015 18:27:22	2 GMT
Ver: IP v4 Diff	(jœ¦uðUCô,,"ؤطف⊄اغ*×ثؤط	Content-Le	ngth: 83831	
Ver: IP v4 Diff			i: keep-alive ied: Thu, 06 Aug 2l	115 20-52-58 GMT
Ver: IP v4 Diff	د,ې+I+چBb [∃] Z:G	ETag: "55c3	c92a-14777"	
Ver: IP v4 Diff	dF+2×-is⁰-1781‰Œέy™	Expires: Sat, Cache-Con	. 06 Aug 2016 18:27 trol: publi	7:22 GMT
Ver: IP v4 Diff	GET /ar/vega/images/bg.g		47 45 54 20 2	



Source IP 10.0.0.18 Source	rce Port
T ID	UDP
Target IP	et Port HTTPS
Direction ALL v	🗆 DNS

Fig.14 Packet filter optionsform showing supported options by NMS

Fig. 15 shows the packets view pane when the user filters packets by source address of value 10.0.0.18 using packet filter options.





Fig. 15 The packets view pane when the user filters packets by source address of value 10.0.0.18 using packet filter options form

Fig. 16 shows the packets view pane when the user filters packets using HTTP protocol and data direction of download using packet filter options.

	Mentfer	Tere	Source	Sarpelart	Declaration	DestinationPort	Protocol	Length	Details	Deta	Detalloary	
	24097	2015-08-07 18	191-234-5-80	80	10.0.0.18	39543	HITP	\$2	Ver: IF v4 (Diff			
	20589	2015-08-07 18	191.234.5.80	80	10.0.0.18	39544	HTTP	\$2	Ver: IP v4 (Diff.			
	20589	2015-08-07 18	191.234.5.80	80	10.0.0.18	35544	HTTP	40	Ver: IP v4 (Diff			
	20590	2015-00-07 18	101.234.5.80	80	10.0.0.18	39544	HTTP	933	Ver: P v4 (Diff	HTTP/3.1 200 OKEache-Control: no-c	43 54 54 50 2	
	20591	2015-08-07 18	191.234.5.80	80	10.0.0.18	33544	HTTP	1991	Ver: F v4 ID#	Ibalianpipo-silanois:-0-18anois	33 62 61 00 0	
	20592	2015-08-07 18	101.234.5.80	80	10.0.0.15	30594	HTTP.	45	Ver: IP v4 (ptff	0	30 00 GA 00 DA	
	20593	2015-08-07 18	191.234.5.80	80	10.0.0.18	39544	HTTP	40	Ver: IP v4 Diff.			
	20594	2015-08-07 18:	191.234.5.80	80	10.0.0.38	39544	HTTP	1452	Ver: Pv410ff	HTTP/1.1 200 OKCache-Control: no-c	48 54 54 50 2	
	23595	2015 08-07 18	191.234.5.80	80	10.0.0.18	33544	HTTP	204	Vor: IP-v4 (Diff	Stamp:to=1439972030-(Instrument	35 35 61 60 7	
	23596	2015-08-07 18	191.234.5.80	80	10.0.0.38	39544	HTTP	327	W: Pv4 DF	18-(Iten)-chano-chest salvegen	51 31 38 00 0	
	20597	2015-08-07 18	191.234.5.80	80	10.0.0.18	28544	HTTP	45	Ver: IP v4 (Diff	0	32 00 GA 00 GA	
	20598	2015-08-07 18	191.234.5.80	80	10.0.0.18	39544	HITP	40	Ver IP v4 (Diff.			
	24093	2015-08-07 18	191.234.5.80	80	10.0.0.15	39343	HTTP	40	Ver: IP v4 Diff			
	24094	2015-08-07 18	191.234.5.00	80	10.0.0.18	39543	HITP	1452	Ver: IP v4 Diff	HTTP/1.1 200 OlCeche-Control: no-c	43 54 54 50 2	
	24095	2015-09-07 18	191.234.5,80	85	10.0.0.18	39543	HITTP	65	Ver: P v4 (0iff	anojsc=0-38empjsp=58emp	61 60 70 36 7	
	\$ 29098	2015-08-07-18:	191.234.5.80	80	10.0.0.18	30543	HTTP	491	Vir: IP v4 (Diff	the;hi=1439973130 <td>31 52 53 00 0</td> <td></td>	31 52 53 00 0	
	24097	2015-00-07 18	191.234.5.80	80	10.0.0.15	39543	HTTP	45	Ver: P v4 Diff	0	30 00 GA 00 GA	
	b 0	2015-08-07 18	162.159.252.143	80	10.0.0.18	39548	HTTP	52	Ver: P v4 (Diff			
	8 0	2015-08-07 18	162.199.252.143	80	10.0.0.18	39547	HTTP	52	Ver: IP v4 (0/F			
	L9380	2015-00-07 18:	162.199.252.143	80	10.0.0.38	33547	HITP	40	Ver: IP v4 (Diff			
ta .					Hexades	imal			P	icket Details		
P/1.1 Is Fri, tenti recti IMod pt "Si ies: 1 he-Ci Cache	200 CK 07 Aug 2015 IB-1 fype: maga/gif congth: 83831 rc lang-alive fact Thu, 05 Aug c3622-14777 et, 05 Aug 2016 I mitoli public, man- filiatus: HT	2015 20:52:58 GMT 1:27:22 GMT			48 5 30 3 65 3 20 4 31 3 4D 5 74 2 9	4 54 50 0 20 4¥ A 20 46 1 75 67 8 3A 32 4 0D 0A D 54 79	2F 31 23 438 0D 04 72 69 20 20 32 30 37 3A 33 43 6F 60 70 65 33 57 69 50	4 44 61 2 20 30 3 31 35 2 32 20 5 74 65 4 20 69	32 ^ 74 37 20 47 6E 50	P Detais mon = P P 4 mon = P P 4 mon = M2 159 135 145 standard Mathematical standard Address = 12, 0.0, 28 metains = Downland 1 = 5 To 3 To 3		

Fig. 16 The packets view pane when the user filters HTTP packets using HTTP protocol and data direction of download using packet filter options form

When the user presses HTTP Filter button, he gets the form shown in Fig.17. The figure displays the HTTP packet filter options supported by the application. Using this form, the user can select one of the options offered and click "Filter" to display HTTP packets in the packets view pane that meet the selected filter options. The user can clear the selected options and start selecting new options again. He can also close the form without taking any action.

			HttpAnalysisFilter		- • • ×
			HTTP Methods	Content Type	HTTP Response
User IP Host Content Size	Greater Tha 🗸		GET POST HEAD PUT DELETE OPTIONS CONNECT TRACE	HTML PHP CSS JS GIF JPG PNG ICO	SUCCESSFUL 2XX REDIRECTION 3XX CLIENT ERROR 4XX SERVER ERROR 5XX
		Filt e	r Clear	Close	

Fig.17 HTTP Filter options form showing supported options by NMS

Fig.18 shows the packets view pane when the user filters HTTP packets and selecting "SUCCESSFUL" HTTP Response using HTTP filter options form.



					HTTPAn	alysis			-								
ć																	
	Liser IP Reques	tTime	Reporce	Plant	HTEP H	athad	Response Status	Response Details	Request URL	^							
	10.0.0.7 R/N/201	58:37:2	8/8/2015 8/37/2	ja-agent.nevreik.com	GET		394	Nithudfed	http://js-agent.nevnels.com/v=632.nen.ja								
	10.0.0.7 8/8/201	58:37:2	8/8/2015 8:37:2	rum collector.pingdom.net	CET		290	OK.	http://run-collector.pingdom.net/ing/beacon.gl								
	10.0.0.7 8/8/205	18:37:2	8/8/2015 8:32:2	greatfind a akanahd net	GET		290	OK.	http://greatford-a.alamahd.net/a24/ubida/82								
			8/8/2015 8:37:2	intelic Jängkookials.com	GRT		290	DK.	http://windc.kangtopdenia.com/fir/ec/Anapfrm.js								
	3 10.0.0.7 s/s/201	5 Ø:37(Z	0/0/2015 0:37:2	bars m-data met	621		290	CK.	http://ban.rr-data.net/1/ide03abb057a=3857								
	10.0.0.7 8/8/201	18:37:2	8/8/2015 8:37.2	reder.oedexis.com	GPT		290	OK.	http://radar.cedexis.com/1/14207/sadar/14390								
		5 8:37:2	8/8/2015 8:37:2	app kingtopdeals.com	GET .		290	OK .	http://epp.kingtopdeals.com/fo/country.gt								
		58:37:2	8/8/2015 8:37:2	radar.cedexis.com	6EL		290	OK .	http://redar.cedexis.com/1439019833/hefer/w								
	\$ 10.0.0.7 0/0/201	9:37:2.	8/8/2015 8:77:2.	e.vtedd.com	GET		290	OK .	http://a.visadd.com/bcript/laver/berve7format +								
	paest Headers HeaderTag	19					pouse Headers HeaderTag		Value								
	HTTPMrthod	GET				•	StatusCole -		304	_							
	Required. RL		632.min js				StatusReason		NotMedified	- 11							
	HIIFVersion		TP/1.1			Date			Sat, 08 Aug 2011 08:37:23 02MT								
	Best									js-agent.newsviic.com Mozilis 5.0 (Windows NT 6.1; WOW64) AppleWebK				ETag		"Bodobielb2be3825b64fcb4334e825"	- 11
	EsserAgent	Mo *)*		s NT 6.3; WOW64) AppleWebK			Connection		keep-alive	- 11							
	Accept						ContentLength		0	- 11							
	AcceptIanguage AcceptEncoding		US,en;q=0.8 p.deflate			1÷.,		_		- 11							
	Connection		p-alive														
	CHINECOM	646	p-arve														
ì		-															
						-											

Fig.18The packets view pane when the user filters HTTP packets by selecting "SUCCESSFUL" HTTP Response using HTTP filter options form

By pressing the HTTP analysis icon (button) in the main window of NMS, a new form is displayed which displays HTTP view pane as shown in Fig.19.The user may press clear button to clear the HTTP view pane.

0 4 🖬								_
User IP	Request Time	Response	Hist	Http Retrad	Response Status	Response Details	RepetURL	^
10.0.0.7	MA201581055	. 8/8/2015 8:35-5	www.alwaterovoka.com	GET	301	NoePersed	http://www.akwstanroice.com/	
18.6.0.7	A/6/2015 B 35 S	. 8,0/2115 8-35-5	www.alwetenvoice.com	GET	200	0(http://www.akestarrrsice.com/krabic/index.html	
15.0.0.7	88/2015 8 25 5	. 8/8/2015 8:35 5	pagead2.googlesyndication.com	GET	304	NetWedfed	http://pageoi/2.googlesyndicator.com/pageod	
18.6.6.7	8/8/2015 8:35:3		pagead2.googlesyndration.com	927	304	NetWedfied	http://pagead2.googlesyndication.com/pagead	
10.0.0.7	8/0/2015/0:35:5	- 0,0/2015 0-25.5	cdr-aptinizely-con	TTD	304	NetMedified	http://ids.aptimizely.com/p/2137590716.jp	
10.00.7			images-alvistanvoice.com	GET	200	06	http://wages.alvatarvoice.com/heirs/arge/99	
10.0.0.7			inages alvataniske.com	GET	200	OK.	http://hages.alvatarvoice.com/hevis/farge/99	
19.8.0.7			inages.aluatanirsice.com	130	200	00	http://mages.alvatanoice.com/neve/Arge/99	
13.6.0.7	\$8,2015 R 25:5.	- MARSENS-	images_aluntanirgice.com	687	200	OK .	http://mages.ainatamoice.com/nexis/large/99	v
HeaderTag		Volue			HeaderTag		Velue	

Fig.19 HTP view pane

The user can select one of the HTTP packets from the HTTP packets view pane as shown in Fig.20.

					HTTPAnaly	sis				
Q	14 🚔									
	User 24	Request Time	Response Time	Proct	Http://etic	od	Response Statue	Response Octain	Request URL	^
	10.0.0.7	6/8/2015 0.25 5	6/0/2015 0:25:5	www.alvatarvoice.com	GET		301	MovedPermanently	http://www.alketanvoice.com/	
	20.0.0.7	8,8(2015 8-25-5	6/8/2015 8:35-5	www.ahatevoice.com	OFT		209	0X	http://www.akvatanceira.com/araits/index.html	
	10.0.0.7	4/8/2015 0:20:5		pagead2.googlesyndication.com	021		304	NotHodfied	http://pagead2.googlesyndication.com/pagead	
	20.0.0.7	4/8/2015 8:25:5	A/8/2015 8135-5	pagead2.googlenyndication.com	130		304	NutHodfiel	http://yapad2.proglas/edication.com/papead	
	30.0.0.7	8/8/2015 9-20-5		cdr.optimaely.com	OET		304	NotHodified	http://cdn.aptexpely.com/jp/2137500716.jp	
	10.0.0.7	8/8/2015 8:35-5	8/8/2015 8:35:5	inages alkatorivoka.com	0ET		200	OK	http://wages.alvatan-oke.com/news/orge/Hill	
	10.0.0.7	6/8/2015 0-25-5		integes alvotariosise.com	GET		200	OK .	http://knages.akuatamusice.com/hervs/large/95	
	ma.a.a.7	8,46(2015 8:25:5	A/6/2015 8135-5	inages elvatorivitie con	GET		200	OK .	http://krages.alvatanusice.com/hevs.farge/NK	
	20.0.0.7	8/8/2015 0.05-5	8/8/2015 8:25:5	inages alvatarioka.com	027		200	OK .	http://mages.alvatamoice.com/nevs/arge/99	~
lequ	est Headers				R	tesps	use Headers	6		
	HeaderTag		Take				HeaderTag		talue	_
•	MTTPM://www.		GET			•	Status Code		280	_
			arabic index.html				StatutReason		OK	_
			RTTP13				Date		lat, 08 Aug 2913 08:35:51 654T	_
			www.alwatasvoite.com				Serier		deadflare-egin	_
			Moella 5.0 (Wesdows NT 6.3; WOW64) AppleWebK						krep-akve	_
			tert bind, application shirs?-and, application and (q=0.8,				CantentType		test blad; charset=UTF-8	_
			R 0-p;m,RU-m						-	_
	AcceptExcoding grip,define					ContentLength			_	
	Coshieofdax8=d1925181873065dd754282bc3c78		13000441342828c3c7E917c1434		•	_			_	
	Cannection		keep alive							

Fig.20 Selection of one HTTP packet that are displayed in the HTTP view pane

When the user selects one HTTP packet from the HTTP view pane, the request header and the response header of the selected packet are displayd as shown in21, and 22 respectively.



	HeaderTag	Value
•	HTTPMethod	GET
	RequiredURL	/arabic/index.html
	HTTPVersion	HTTP/1.1
	Host	www.alwatanvoice.com
	UserAgent	Mozilla/5.0 (Windows NT 6.3; WOW64) AppleWebK
	Accept	text/html,application/xhtml+xml,application/xml;q=0.9,
	AcceptLanguage	en-US,en;q=0.8
	AcceptEncoding	gzip,deflate
	Cookie	cfduid=d1925181673060dd754282bc5c787f17c1434
	Connection	keep-alive
*		

	HeaderTag	Value		
•	StatusCode	200		
	StatusReason	OK		
	Date	Sat, 08 Aug 2015 08:35:51 GMT		
	Server	cloudflare-nginx		
	Connection	keep-alive		
	ContentType	text/html; charset=UTF-8		
	ContentEncoding	gzip		
	ContentLength	0		
*				

Fig.22 Response header of selected HTTP packet

To generate file(s) from captured packets, the user has to select a packet from the packets view pane first. Then, he presses the folder icon (file generation button) to run File Generation module. This button is displayed in the the toolbar in the main window of NMS. File Generationform will appear as shown in Fig.23. Fig.23 lets the user select one of file generationmodes as described in subsection 3.2.9. File generation form also lets the user choose the destination folder of the file(s) to be generated.

After the user pressing the file generation button and selecting the destination folder, he could press "Extract" button in the file generation form. An example of file generation is shown in Fig. 24. Fig. 24 displays the folder "d:\MY_Data" that contains the files generated from the packets. In this example, the user chooses the selected host mode and alwatanvoice.com as the host name (the selected packet contains this host the server name).

uest Time Response Time		nse	Host	Http Method	Response Status	Respo Details
2015 8:37:2	8/8/20	15 8:37:2	js-agent.newrelic.com	GET	304	NotMod
2015 8:37:2	8/		Extra	ctFiles	- 🗆 🗙	ОК
2015 8:37:2	8/					OK
2015 8:37:2	8/					OK
2015 8:37:2	8/					ОК
2015 8:37:2	8/	• Th	e Selected File =>> cd	e03abb06		ОК
2015 8:37:2	8/					OK
2015 8:37:2	8/	O Th	e Selected Host =>> ba	m.nr-data.net		ОК
2015 8:37:2	8/					OK
	alue		e Selected User =>> 10 act Path			
GE		D:\M	/data		1.00	
	cde					
	TTF		Extract	Close		
	m.r		Extract	Close		
	ozil					
*/	*			- T		
1000	-US,en;	2 0-0				

Fig.23File generation form





Fig.24An example of file generation

The results of above experiments show that NMS runs correctly and efficiently. It monitors NICs, it captures packets, it parses packets, it filters packets, and it builds files from packets. In short, it does what is was intended to do correctly and accurately.

NMS design enables ISPs to overcome the lack of the tools to support low level packet sniffing and monitoring. In addition, most of the present tools do not have the ability restore the original files from the intercepted packets. Also, current similar tools are very expensive tompared to NMS.

V. CONCLUSION

This paper dsigns a network monitoring system called NMS.Using NMS we could view data transmitted over the computer networks and crossing NICs connected to our computers. This enables us to analyse packets and data, detect malicious behavior, and produce warning messages. The network administrator can use NMS to monitor and analyse packets over the network and build network intrusion detection systems.

Challenges that face the design of intrusion detection systems, packet filtering, and data analysis like the one proposed in this paper include processing high-volume of data, possibility of packet loss/drop, and the requirement for system flexibility and scalability. To overcome thesechallenges, we developed the system using low level packet sniffing and C# which is very powerfull in regards to memory management. In addition, we applied some ideas from adaptive pattern matching techniques. One of the key components in NMS is HTTP filter analysis and file generation from pure packets.NMS could invistigate all traffic that is specific to a single user, or specific to a single host. The proposed application could save such traffic in any destination folder for later analysis (offline analysis). NMS could detect malicious traffic in real time. The user of the proposed system could do many statistics on collected data based onvisited hosts, the contents of generated files. Current version of NMS focuses on HTTP protocol.

e could enhance and improve NMS as follows: support, filter and snif other protocols that are not currently supported, add more filters to the packets (filter by text content, Internet browser used, date and time, ...), add the other protocols analysis (DNS, ICMP, POP3,), extractsecrets key of HTTPS, support the password sniffing, decrypt HTTPS data and extract files from it, detect malicious behavior (man in the middle, DNS poisoning, fishing, ...), create alert systems to send warnings when malicious behavior is detected, and finally, add a module to edit received packets and retransmit them.

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