Ethernet II

	Preamble	Destination address	Source address	EtherType	Data	FCS
į	8B	6B	6B	2B	46 - 1500 B	4B

Novell 802.3 RAW (Novell proprietary)

Preamble	Destination address	Source address	Length	FFFF IPX header	Data	FCS
8B	• 6B	• 6B	• 2B	3B	43 - 1497 B	• 4B

IEEE 802.3 LLC

Preamble	Destination address	Source address	Length	DSAP	SSAP	Control	Data	FCS
8B	6B	6B	2B	1B	1B	1B	43 - 1497 B	4B

IEEE 802.3 LLC + SNAP

Pream	Destination address	Source address	Length	DSAP	SSAP	Control	Vendor Code	EtherType	Data	FCS
8B	6B	6B	2B	1B	1B	1B	3B	2B	38 - 1492 B	4B
	Data Link Header			Log	jical Link Hea	ader	SNĀP	Header		

	02.2 LLC Service Access Points (SAPs)					
Hex	Dec	Function				
00	0	Null SAP				
02	2	LLC Sublayer Management / Individual				
03						
06	· ·					
0E	14	PROWAY (IEC 955) Network Management, Maintenance and Installation				
42	66	BPDU (Bridge PDU / 802.1 Spanning Tree)				
4E	78	MMS (Manufacturing Message Service) EIA-RS 511				
5E	94	ISI IP				
7E	126	X.25 PLP (ISO 8208)				
8E	142	PROWAY (IEC 955) Active Station List Maintenance				
AA	170	SNAP (Sub-Network Access Protocol / non-IEEE SAPs)				
E0	224	IPX (Novell NetWare)				
F4	244	LAN Management				
FE	254	ISO Network Layer Protocols				
FF	255	Global DSAP				

EtherTyp	EtherType values					
google for	oogle for "IANA Ether Types" for up-to-date list					
Hex	Dec	Description				
0200	0512	XEROX PUP				
0201	0513	PUP Addr Trans				
0800	2048	Internet IP (IPv4)				
0801	· ·					
0805	805 2053 X.25 Level 3					
0806	2054	ARP (Address Resolution Protocol)				
8035	32821	Reverse ARP				
809B	32923	Appletalk				
80F3	33011	AppleTalk AARP (Kinetics)				
8100	33024	IEEE 802.1Q VLAN-tagged frames				
8137	33079	Novell IPX				
86DD	34525	IPv6				
880B	34827	PPP				
8847	34887	MPLS				
8848	34888	MPLS with upstream-assigned label				
8863	34915	PPPoE Discovery Stage				
8864	34916	PPPoE Session Stage				

UDP Header

Bit Number

1111111111222222222233

01234567890123456789012345678901

Source Port	Destination Port
Length	Checksum

UDP Header Information

Common UDP Well-Known Server Ports 7 echo 138 netbios-dgm 19 chargen 161 snmp 37 time 162 snmp-trap 53 domain 500 isakmp 67 bootps (DHCP) 514 syslog 68 bootpc (DHCP) 520 rip 69 tftp 33434 traceroute

137 netbios-ns

Length

(Number of bytes in entire datagram including header;

Checksum

(Covers pseudo-header and entire UDP datagram)

ARP

Bit Number

111111111122222222233

01234567890123456789012345678901

Hardware A	ddress Type	Protocol Address Type		
H/w Addr Len Prot. Addr Len		Operation		
Source Hardware Address				
Source Hardwo	are Addr (cont.)	Source Protocol Address		
Source Protoc	ol Addr (cont.)	Target Hardware Address		
Target Hardware Address (cont.)				
Target Protocol Address				

ARP Parameters (for Ethernet and IPv4)

Hardware Address Type

- 1 Ethernet
- 6 IEEE 802 LAN

Protocol Address Type

2048 IPv4 (0x0800)

Hardware Address Length

6 for Ethernet/IEEE 802

Protocol Address Length

4 for IPv4

Operation

- 1 Request
- 2 Reply

DNS

Bit Number

111111

	ID.							
QR	QR Opcode AA TC RD RA Z RCODE							
	QDCOUNT							
	ANCOUNT							
	NSCOUNT							
	ARCOUNT							
	Question Section							
	Answer Section							
	Authority Section							
	Additional Information Section							

DNS Parameters

Query/Response

- 0 Query
- 1 Response

0pcode

- 0 Standard query (QUERY)
- 1 Inverse query (IOUERY)
- 2 Server status request (STATUS)

2.2

(1 = Authoritative Answer)

TC

(1 = TrunCation)

RD

(1 = Recursion Desired)

RA

(1 = Recursion Available)

(

Z
(Reserved; set to 0)

.

Response code 0 No error

- 1 Format error
- 1 Format error
- 2 Server failure
- 3 Non-existant domain (NXDOMAIN)
- 4 Query type not implemented
- 5 Query refused

QDCOUNT

(No. of entries in Question section)

ANCOUNT

(No. of resource records in Answer section)

NSCOUNT

(No. of name server resource records in Authority section)

ARCOUN

(No. of resource records in Additional Information section.



TCP/IP and tcpdvmp

POCKET REFERENCE GUIDE

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tcpdump Usage

tcpdump [-aenStvx] [-F file]
[-i int] [-r file] [-s snaplen]
[-w file] ['filter_expression']

- -e Display data link header.
- -F Filter expression in file.
- -i Listen on int interface.
- -n Don't resolve IP addresses.
- -r Read packets from file.
- -s Get snaplen bytes from each packet.
- -S Use absolute TCP sequence numbers.
- -t Don't print timestamp.
- -v Verbose mode.
- -w Write packets to file.
- -x Display in hex.

Authentication Header (RFC 2402)

Address Resolution Protocol (RFC 876)

Border Gateway Protocol (RFC 1771)

Domain Name System (RFC 1035)

File Transfer Protocol (RFC 959)

Don't Fragment bit (IP)

FIGRP Extended IGRP (Cisco)

IMAP

Congestion Window Reduced (RFC 2481)

Explicit Congestion Notification (RFC 3168)

Encapsulating Security Payload (RFC 2406)

Generic Routing Encapsulation (RFC 2784)

Internet Control Message Protocol (RFC 792)

Internet Group Management Protocol (RFC 2236)

Hypertext Transfer Protocol (RFC 1945)

Interior Gateway Routing Protocol (Cisco)

Internet Protocol (RFC 791)

Internet Message Access Protocol (RFC 2060)

Dynamic Host Configuration Protocol (RFC 2131)

-X Display in hex and ASCII.

Acronyms

ISAKMP Internet Security Association & Key Management Protocol (RFC 2408) L2TP Layer 2 Tunneling Protocol (RFC 2661)

NNTP Network News Transfer Protocol (RFC 977)
OSPF Open Shortest Path First (RFC 1583)

POP3 Post Office Protocol v3 (RFC 1460)

RFC Request for Comments

RIP Routing Information Protocol (RFC 2453)

LDAP Lightweight Directory Access Protocol (RFC 2251)
SKIP Simple Key-Management for Internet Protocols

SMTP Simple Mail Transfer Protocol (RFC 821)

SMMP Simple Mail Transfer Profocol (RFC 821)
SNMP Simple Network Management Profocol (RFC 1157)

SSH Secure Shell

SSL Secure Sockets Layer (Netscape)
TCP Transmission Control Protocol (RFC 793)

TFTP Trivial File Transfer Protocol (RFC 1350)

TOS Type of Service field (IP)

UDP User Datagram Protocol (RFC 768)

All RFCs can be found at http://www.rfc-editor.org

@SANS Institute June 2002

Bit Number

111111111122222222233

01234567890123456789012345678901

Туре	Code	Checksum			
Other message-specific information					

Type Name/Codes (Code=0 unless otherwise specified)

- 0 Echo Reply
- 3 Destination Unreachable
 - 0 Net Unreachable
 - 1 Host Unreachable
 - 2 Protocol Unreachable
 - 3 Port Unreachable
 - 4 Fragmentation Needed & DF Set
 - 5 Source Route Failed
 - 6 Destination Network Unknown
 - 7 Destination Host Unknown
 - 8 Source Host Isolated
 - 9 Network Administratively Prohibited
 - 10 Host Administratively Prohibited
 - 11 Network Unreachable for TOS
 - 12 Host Unreachable for TOS
 - 13 Communication Administratively Prohibited
- 4 Source Ouench
- 5 Redirect
 - 0 Redirect Datagram for the Network
 - 1 Redirect Datagram for the Host
 - 2 Redirect Datagram for the TOS & Network
 - 3 Redirect Datagram for the TOS & Host
- 8 Echo
- 9 Router Advertisement
- 10 Router Selection
- 11 Time Exceeded
 - 0 Time to Live exceeded in Transit 1 Fragment Reassembly Time Exceeded
- 12 Parameter Problem
 - O Pointer indicates the error
 - 1 Missing a Required Option
- 2 Bad Length
- 13 Timestamp
- 14 Timestamp Reply
- 15 Information Request
- 16 Information Reply
- 17 Address Mask Request
- 18 Address Mask Reply
- 30 Traceroute

PING (Echo/Echo Reply)

Bit Number

11111111111222222222233

01234567890123456789012345678901

Type (8 or 0) Code (0)		Checksum			
Ident	ifier	Sequence Number			
Data					

IP Header

Bit Number

11111111111222222222233

01234567890123456789012345678901

Version	IHL	Type of Service		Total Length		
	Identif	ication	Flags Fragment Offset			
Time t	Time to Live Protocol			Header Checksum		
	Source Address					
Destination Address						
	Options (optional)					

IP Header Contents

Version

4 IP version 4

Internet Header Length

Number of 32-bit words in IP header; minimum value = 5 (20 bytes) & maximum value = 15 (60 bytes)

Type of Service (PreDTRCx) --> Differentiated Services

Precedence (000-111) D (1 = minimize delay)											
D	(1	=	minimize	delay)	0						
T	(1	=	maximize	throughout)	0						
R	(1	=	maximize	reliability)	0						

1 = ECN capable C (1 = minimize cost)

1 = congestion experienced x (reserved and set to 0)

Total Length

Number of bytes in packet: maximum length = 65,535

Flags (xDM)

x (reserved and set to 0) D (1 = Don't Fragment) M (1 = More Fragments)

Fragment Offset

Position of this fragment in the original datagram, in units of 8 bytes

Protocol

1	ICMP	17	UDP	57	SKIP
2	IGMP	47	GRE	88	EIGRP
6	TCP	50	ESP	89	OSPF
9	IGRP	51	AH	115	L2TP

Header Checksum

Covers IP header only

Addressing

NET_ID		RFC 1918 PRIVATE ADDRESSES
0-127	Class A	10.0.0.0-10.255.255.255
128-191	Class B	172.16.0.0-172.31.255.255
192-223	Class C	192.168.0.0-192.168.255.255
224-239	Class D	(multicast)
240-255	Class E	(experimental)
HOST ID		
_ 0	Network	value; broadcast (old)
255	Broadca	st

Options (0-40 bytes; padded to 4-byte boundary)

0	End of Options list	68	Timestamp
1	No operation (pad)	131	Loose source route
7	Record route	137	Strict source route

TCP Header

Bit Number

1111111111222222222233

01234567890123456789012345678901

0,20400,0,0120400,0,0120400,0,01								
	Source Por	rt	Destination Port					
Sequence Number								
Acknowledgment Number								
Offset (Heoder Length)	Reserved	Flags	Window					
	Checksum	1	Urgent Pointer					
	Options (optional)							

TCP Header Contents

```
Common TCP Well-Known Server Ports
   7 echo
                               110 pop3
                               111 sunrpc
  19 chargen
  20 ftp-data
                               119 nntp
  21 ftp-control
                               139 netbios-ssn
                               143 imap
  22 eeh
                               179 bqp
  23 telnet
  25 smtp
                                389 ldap
  53 domain
                               443 https (ssl)
  79 finger
                               445 microsoft-ds
  80 http
                              1080 socks
```

Offset

Number of 32-bit words in TCP header; minimum value = 5

```
4 bits; set to 0
ECN bits (used when ECN employed; else 00)
   CWR (1 = sender has cut congestion window in half)
   ECN-Echo (1 = receiver cuts congestion window in half)
```

Flags (UAPRSF)

U (1 = Urgent pointer valid)

A (1 = Acknowledgement field value valid)

P (1 = Push data)

R (1 = Reset connection)

S (1 = Synchronize sequence numbers)

F (1 = no more data: Finish connection)

Covers pseudoheader and entire TCP segment

Urgent Pointer

Points to the sequence number of the byte following urgent data.

Options

0 End of Options list	3 Window scale
1 No operation (pad)	4 Selective ACK ok
2 Maximum segment size	8 Timestamp

Options Headers (Hop-by-Hop Options and Destination Options) Bit Number 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 Next Header Hdr Ext Len **Options**

Next Header

8-bit identifier for the header immediately following this one. Uses the same codes as the main IPv6 header.

Hdr Ext Len

8-bit length of the Hop-by-Hop Options header in 8-octet units not including the first 8 octets, i.e. (length in octets-8)/8.

Variable-length field, containing the options. NOTE: length must be a multiple of 8 octets long.

Option Encoding:



Option Type	8-bit Identifier
WW	indicate what to do if this option is not recognized:
00	skip this option and continue processing the header.
01	discard packet.
10	discard packet and send an ICMP Parameter Problem code 2 back to the source address pointing to the unrecognized Option Type.
11	discard packet and, if destination is not a multicast address, behave like type 10.
С	indicates whether the option data for this option can change en-route to the destination. Relevant if, in particular, an AH is present.
0	no change
1	can change
ШП	rest of the option type code
Opt Data	a Len

8-bit length of the Option Data field of this option, in octets.

Option Data

Variable-length field.

Options which must be implemented:

i) Pad1 option, special case:

0 1 2 3 4 5 6 7 0

NOTE: no length or field values!

ii) PadN option:

Г				1				П	0	pt	Da	ta	Ler	ī	Г	Option Data
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	
										1	1	1	1	1	1	

Routing Header (similar to IPv4 LSRR and RR options)

Next Header	Hdr Ext Len	Routing Type	Segments Left								
type-specific data											

8-bit identifier for the header immediately following this one. Uses the same codes

8-bit length of the Hop-by-Hop Options header in 8-octet units not including the first 8 octets, i.e. (length in octets-8)/8.

Routing Type

8-bit identifier

Segments Left

8-bit integer giving the number of listed intermediate nodes which still need to be visit-

Variable-length field which depends on the routing type. Must be a multiple of 8 octets.

Only one routing header type has been defined, type 0:

Next Header	Hdr Ext Len	Routing Type = 0	Segments Left	4							
Reserved (MBZ)											
	Address[1]										
				24							
				28							
	Addr	ess[2]		32							
	Addi	000[2]		36							
				40							
	Adde	ess[n]									
	Auu	esse[ii]									
				-							



IPv6 TCP/IP and tcpdump



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tcpdump Usage

tcpdump [-aenStvx] [-F file] [-i int] [-r file] [-s snaplen] [-w file] ['filter_expression']

- -e Display data link header.
- -F Filter expression in file.
- -i Listen on int interface.
- -n Don't resolve IP addresses.
- -r Read packets from file.
- -s Get snaplen bytes from each packet.
- -S Use absolute TCP sequence numbers.
- t Don't print timestamp.
- v Verbose mode.
- -w Write packets to file.
- -x Display in hex.
- -X Display in hex and ASCII.

Acronyms

ı				
ı	AH	Authentication Header (RFC 2402)	ISAKMP	Internet Security Association & Key Management
ı	ARP	Address Resolution Protocol (RFC 826)		Protocol (RFC 2408)
ı	BGP	Border Gateway Protocol (RFC 1771)	L2TP	Layer 2 Tunneling Protocol (RFC 2661)
ı	CWR	Congestion Window Reduced (RFC 2481)	NNTP	Network News Transfer Protocol (RFC 977)
ı	DF	Don't Fragment bit (IP)	OSPF	Open Shortest Path First (RFC 1583)
ı	DHCP	Dynamic Host Configuration Protocol (RFC 2131)	POP3	Post Office Protocol v3 (RFC 1460)
ı	DNS	Domain Name System (RFC 1035)	RFC	Request for Comments
ı	ECN	Explicit Congestion Notification (RFC 3168)	RIP	Routing Information Protocol (RFC 2453)
ı	EIGRP	Extended IGRP (Cisco)	LDAP	Lightweight Directory Access Protocol (RFC 2251
ı	ESP	Encapsulating Security Payload (RFC 2406)	SKIP	Simple Key-Management for Internet Protocols
ı	FIP	File Transfer Protocol (RFC 959)	SMIP	Simple Mail Transfer Protocol (RFC 821)
ı	GRE	Generic Routing Encapsulation (RFC 2784)	SNMP	Simple Network Management Protocol (RFC 115
ı	НПТР	Hypertext Transfer Protocol (RFC 1945)	SSH	Secure Shell
ı	ICAP	Internet Control Message Protocol (RFC 792)	SSL	Secure Sockets Layer (Netscape)
ı	IGMP	Internet Group Management Protocol (RFC 2236)	TCP	Transmission Control Protocol (RFC 793)
ı	IGRP	Interior Gateway Routing Protocol (Cisco)	IFIP	Trivial File Transfer Protocol (RFC 1350)
ı	IMAP	Internet Message Access Protocol (RFC 2060)	TOS	Type of Service field (IP)
ı	IP	Internet Protocol (RFC 791)	UDP	User Datagram Protocol (RFC 768)
ı		All RFCs can be found at	http://v	www.rfc-editor.org

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Bit Number

0 1 2 3 4 5 6 7 8 0 0 1 1 1 1 1 1

•	1 2	_	-	_			0	,	0 1	-	, ,	
ID.												
QR	Ор	ode		AA	TC	RD	RA		Z		RCOD	Ε
	QDCOUNT											
	ANCOUNT											
						NSC	DUNT					
						ARC	DUNT					
					Qu	estion	Sect	ion				
					An	swer	Secti	on				
	Authority Section											
				Addit	tional	Infor	matio	n Sec	tion			

Ouery/Response

O Query

1 Response

- O Standard query (QUERY)
- 1 Inverse query (IQUERY)
- 2 Server status request (STATUS)

(1 = Authoritative Answer)

TC

(1 = TrunCation)

(1 = Recursion Desired)

(1 = Recursion Available)

(Reserved; set to 0)

0 No error

1 Format error

2 Server failure

3 Non-existant domain (NXDOMAIN)

4 Query type not implemented

5 Query refused

ODCOUNT

(No. of entries in Question section)

(No. of resource records in Answer section)

(No. of name server resource records in Authority section)

(No. of resource records in Additional Information section.

IPv6 Header Bit Number

Version	Traffic Class	Flow Label			
	Payload Length		Next Header	Hop Limit	8
Source Address					1
					2
					2
					2
Destination Address				33	
				3	
					4

Version

4.hit Internet Protocol version number = 6

Traffic Class

8-bit traffic class field (Experimental)

Default = 0

To be used for QoS and traffic prioritisation

Flow Label

20-bit flow label (Experimental)

Default = 0

Used in association with "traffic class" to label packets for QoS.

Payload Length

16-bit integer.

Payload length in octets (packet - header)

NOTE: extension headers are considered part of the payload!

Next Header

8-bit "selector". Identifies the type of header immediately following the IPv6 header.

Some examples:

- O Hop-by-Hop Options (NOTE; special processing)
- 43 Routing (Type 0)
- 44 Fragment
- 50 Encapsulating Security Payload
- 51 Authentication
- 58 ICMPv6
- 59 No next header
- 60 Destination Options

Standard headers inherited from IPv4:

- 6 TCP
- 17 LIDP

Hop Limit

8-bit unsigned integer. Decremented by 1 by each node that forwards the packet. The packet is discarded if Hop Limit is decremented to zero.

Source Address

128-bit source address

Destination Address

128-bit destination address

NOTE: not necessarily the final destination if a Routing header is present!

TCP Header Bit Number

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0

Source Port			Destination Port		
Sequence Number					
Acknowledgment Number					
Offset (Header Leagth)	Reserved	Flags	Window		
	Checksur	n	Urgent Pointer		
Options (optional)					

Common TCP Well-Known Server Ports

7 echo 110 pop3 19 chargen 111 sunroc 20 ftp-data 119 nnto 139 netbios-ssn 21 ftp-control 22 ssh 143 imap 23 tolnot 179 bgp 25 smtp 389 Idap 53 domain 443 https (ssl) 79 finger 445 microsoft-ds 80 http 1080 socks

Offset

Number of 32-bit words in TCP header; minimum value = 5

Reserved

4 bits: set to 0

ECN bits (used when ECN employed; else 00)

CWR (1 = sender has cut congestion window in half)

ECN-Echo (1 = receiver cuts congestion window in half)

Flags (UAPRSF)

- U (1 = Urgent pointer valid)
- A (1 = Acknowledgement field value valid)
- P (1 = Push data)
- R (1 = Reset connection)
- S (1 = Synchronize sequence numbers)
- F (1 = no more data; Finish connection)

Checksum

Covers pseudoheader and entire TCP segment

Urgent Pointer

Points to the sequence number of the byte

following urgent data.

Options |

0 End of Options list 3 Window scale 1 No operation (pad) 4 Selective ACK ok 2 Maximum segment size 8 Timostamn

UDP Header

Bit Number

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1

Source Port	Destination Port	4
Length	Checksum	8

Common UDP Well-Known Server Ports

7 echo 138 netbios-dgm 19 chargen 161 snmp 37 time 162 snmp-trap 53 domain 500 isakmp 67 bootps (DHCP) 514 syslog 68 bootpc (DHCP) 520 rip 33434 traceroute 69 tftp 137 netbios-ns

Length

(Number of bytes in entire datagram including header; minimum value = 8)

Checksum

(Covers pseudo-header and entire UDP datagram)

ICMPv6 (header type 58)

Bit Number

Checksum

Message Body

Code Type

Type

		destination

- communication administratively prohibited
 - (not assigned)
 - address unreachable
 - port unreachable

packet too big message, message body contains

- MTU of next hop link.
- hop limit exceeded in transit
- fragment reassembly time exceeded
- 0 erroneous header field encountered
 - unrecognized "Next Header" type encountered unrecognized IPv6 option encountered
- 128 0 echo request
- 129 0 echo reply

Fragment Header

Note: fragmentation can only be performed by the source nodes, not routers!

Bit Number

Next Header	Reserved	Fragment Offset		M	ŀ	
Identification						

8-bit identifier for the header immediately following this one. Uses the same codes as the main IPv6 header.

8-bit reserved field. Initialized to zero for transmission; ignored on reception.

Fragment Offset

13-bit unsigned integer. The offset, in 8-octet units, of the data following this header, relative to the start of the data which can be fragmented of the original packet. Note that the IPv6 header and extensions headers which need to be processed at every hop cannot be fragmented! [This is known as the "Unfragmentable Part" in IPv6 jargon].

2-bit reserved field. Initialized to zero for transmission; ignored on reception.

M flag

1 = more fragments: 0 = last fragment.

Identification

32 bits identifier for reassembly.

Checksums

The IPv6 header does not include checksums on the assumption that if checksumming is required then it will be done via an AH header which provides cryptographically strong authentication (and hence a checksum) of the whole packet. There remains an issue with upper-layer protocols, for exmaple TCP and UDP which include a checksum calculation. In particular the "pseudo-header" to be used in IPv6 TCP/UDP checksum calculations is:

Bit Number

Source Address Destination Address Upper-Layer Packet Length

Note: unlike IPv4 the UDP checksum is compulsory when carried over IPv6!

Next Header

Must be Zero (MBZ)