

UDP Header

	0	1	2	3
0	Source Port		Destination Port	
4	Length		Checksum	

Common UDP Ports

7	echo	137	netbios-ns	546	DHCPv6c
19	chargen	138	netbios	547	DHCPv6s
53	domain	161	snmp	1900	SSDP
67	DHCPc	162	snmp-trap	5353	mDNS
68	DHCPs	500	isakmp		
69	tftp	514	syslog		
123	ntp	520	Rip		

Length: number of bytes including UDP header.  
Minimum value is 8  
Checksum includes pseudo-header (IPs, length, protocol), UDP header and payload.

ARP

	0	1	2	3	
0	HW Addr. Type		Prot. Addr. Type		
4	HW Addr Len.	Prot. Addr Len	Opcode		
8	Source Hardware Addr.				
12	Src HW Addr		Src Protocol Addr		
16	Src. Proto Addr		Tgt HW Addr		
20	Tgt HW Address (cont.)				
24	Target Protocol Address				

Hardware Type: 1 - Ethernet  
Protocol Type: 0x0800 - IPv4  
Address Length: 4=IPv4, 6=Ethernet  
Opcode: 1-request, 2-response



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# TCP/IP and tcpdump

Version June 2016

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## POCKET REFERENCE GUIDE

Please submit comments and corrections to [jullrich@sans.edu](mailto:jullrich@sans.edu)  
<https://www.sans.org/security-resources/tcpip.pdf>

### COURSES & GIAC CERTIFICATIONS

SEC503 Intrusion Detection In-Depth	
SEC 401 Security Essentials	
SEC 502 Perimeter Protection	
SEC 560 Network Penetration Testing	
SEC 546 IPv6 Security Essentials	
FOR 572 Network Forensics	
MGT512 Security Leadership Essentials	

### tcpdump usage

```
tcpdump [-aAenStvxX] [-F filterfile] [-i int] [-c n]
[-r pcapfile] [-s snaplen] [-w pcapfile] ['bpf filter']
```

- A display payload
- c n display first n packets
- D list interfaces
- e display data link header
- F read filter expression from file
- i listen on specified interface
- n do not resolve IP addresses / ports
- r read packets from file
- s set snap length in bytes
- S display absolute TCP sequence numbers
- t do not print timestamp
- tttt print date and time
- v verbose (multiple v: more verbose)
- w write packets to file
- x display in hex
- xx display link layer in hex
- X display in hex + ASCII

### Acronyms

AH	Authentication Header (RFC 2402)
ARP	Address Resolution Protocol (RFC 826)
BGP	Border Gateway Protocol (RFC 1771)
CWR	Congestion Window Reduced (RFC 2481)
DF	Do not fragment flag (RFC 791)
DHCP	Dynamic Host Configuration Protocol (RFC 2131)
DNS	Domain Name System (RFC 1035)
ECN	Explicit Congestion Notification (RFC 3168)
ESP	Encapsulating Security Payload (RFC 2406)
FTP	File Transfer Protocol (RFC 959)
GRE	Generic Route Encapsulation (RFC 2784)
HTTP	Hypertext Transfer Protocol (RFC 1945)
ICMP	Internet Control Message Protocol (RFC 792)
IGMP	Internet Group Management Protocol (RFC 2236)
IMAP	Internet Message Access Protocol (RFC 2060)
IP	Internet Protocol (RFC 791)
ISAKMP	Internet Sec. Assoc. & Key Mngm Proto. (RFC 7296)
L2TP	Layer 2 Tunneling Protocol (RFC 2661)
OSPF	Open Shortest Path First (RFC 1583)
POP3	Post Office Protocol v3 (RFC 1460)
RFC	Request for Comments
SMTP	Simple Mail Transfer Protocol (RFC 821)
SSH	Secure Shell (RFC 4253)
SSL	Secure Sockets Layer (RFC 6101)
TCP	Transmission Control Protocol (RFC793)
TLS	Transport Layer Security (RFC 5246)
TFTP	Trivial File Transfer Protocol (RFC 1350)
TOS	Type of Service (RFC 2474)
UDP	User Datagram Protocol (RFC 768)

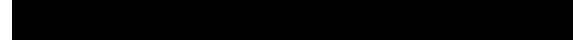
DNS				
	0	1	2	3
0	Query ID		Flags (see below)	
4	Query Count		Answer Count	
8	Authority Rec. #		Addtl. Record #	
12	Questions... Answers... Authority Records... Additional Records...			

Flags:

Byte Offset 2							Byte Offset 3								
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
Q	OPCODE				A	T	R	R	Z	A	C	RCODE			
R					A	C	D	A		D	D				

QR:       Query (0) or Response (1)  
Opcode: 0 – std. Query, 1 – inverse query (IQUERY), 2 – Server Status (STATUS)  
AA:       Authoritative Answer  
TC:       Truncated response  
RD       Recursion Desired  
RA       Recursion Available  
Z         Zero (set to 0)  
AD       Authentic Data(DNSSEC)  
CD       Checking Disabled (DNSSEC)

RCODE:  
0 – No error  
1 – Format Error  
2 – Server Failure  
3 – Non-existent domain (NXDOMAIN)  
4 – Query type not implemented  
5 – Query refused



ICMP

	0	1	2	3
0	Type	Code	Checksum	
4	Addtl. information depending on type/code			

Type	Code	Name
0	0	Echo Reply
3	0	Network Unreachable
	1	Host Unreachable
	2	Protocol Unreachable
	3	Port Unreachable
	4	Fragmentation Required
	5	Source Route Failed
	6	Dest. Network Unknown
	7	Destination Host Unknown
	8	Source Host Isolated
	9	Net Administratively Prohibited
	10	Host Administratively Prohibited
	11	Network unreachable for TOS
	12	Host unreachable for TOS
	13	Communication Admin. Prohibited
	4	Source quench
	5	Network Redirect
	1	Host Redirect
	2	ToS & Network Redirect
	3	ToS & Host Redirect
8	0	Echo [Echo Request]
9	0	Router Advertisement
11	0	Time to live exceeded in transit
	1	Fragment Reassembly time exceeded
12	0	Parameter Prob. Pointer indicated the error
	1	Missing a required option
	2	Bad length
13	0	Timestamp
14	0	Timestamp Reply
15	0	Information Request
16	0	Information Reply
17	0	Address Mask Request
18	0	Address Mask Reply
30	0	Traceroute

ICMP Echo Request/Reply (Ping)				
	0	1	2	3
0	Type	Code	Checksum	
4	ICMP ID		ICMP Sequence	

IPv4 Header

Offset: Add column+row. e.g. Protocol=9

ip[9] = “IP header offset 9” or the protocol field

	0	1	2	3			
0	Ver	IHL	TOS	Total Length			
4	IP Identification			X	D	M	Offset
8	TTL		Protocol	Checksum			
12	Source Address						
16	Destination Address						
20	Options (optional)						

Version: 4 ip[0]&0xf0  
Header Length: IP header length in double-words (4 bytes). Minimum 5 (20 bytes)

ToS/Differentiated Services Byte ip[1]							
0	1	2	3	4	5	6	7
Diff. Svc. Code Point						ECN	

Total Length: includes header ip[2:2]  
Flags ip[6]  
0 1 2 3 4 5 6 7  
X D M O O O O O  
X: Reserved, D: Do Not Frag. M: More Fragments  
O: Offset bits

Fragment Offset: position of this ip datagram’s payload in original packet (multiply by 8)							
Protocol ip[9]							
1	ICMP	17	UDP	50	ESP		
2	IGMP	41	IPv6	51	AH		
6	TCP	47	GRE	115	L2TP		

Checksum: IP Header Only

Options: up to 40 bytes, 4 byte padded ip[20..]							
0	End of Options List		68	Timestamp			
1	No Operation		131	Loose source route			
7	Record Route		137	Strict Source Route			



TCP							
	0	1	2	3			
0	Source Port			Dest. Port			
4	Sequence Number						
8	Acknowledgement Number						
12	HL	R	Flags	Window Size			
16	Checksum			Urgent Pointer			
20	Options (up to 40 bytes)						

Common TCP Ports

20	ftp-data	80	http	443	https
21	ftp	88	kerberos	445	MS SMB
22	ssh	110	pop3	465	SMTPS
23	telnet	113	authd	1433	MS SQL
25	smtp	119	nnntp	3128	Squid
43	whois	143	imap	3306	Mysql
53	dns	179	bgp	3389	MS Term.

Advanced

- Sequence Number tcp[4:4]: increments with each byte
- Ack. Number tcp[8:4]: next expected sequence number
- Header Length tcp[12]>>4: TCP Header Length / Offset; minimum 5. Number of 32 bit dwords (4 bytes)
- Reserved tcp[12]&0x0f: Set to 0
- Flags tcp[13]

7	6	5	4	3	2	1	0
8	4	2	1	8	4	2	1
CWR	ECE	URG	ACK	PUSH	RES	SYN	FIN

Window Size tcp[14:2]: recv. Window size  
Checksum tcp[16:2]: Covers pseudo-header + TCP Header + TCP Payload  
Urgent Point tcp[18:2]: Offset pointer to urgent data  
Options tcp[20:...]

0	End of List			3	Window Scale		
1	No Operation			4	Selective Ack OK		
2	Max. Segment Size			8	Timestamp		
29	TCP Auth Option			30	Multipath TCP		