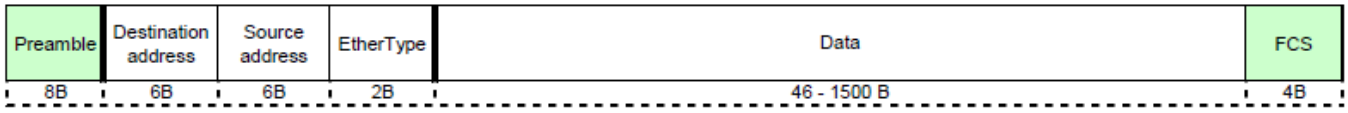
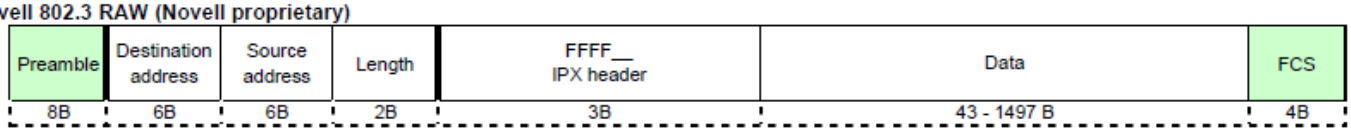
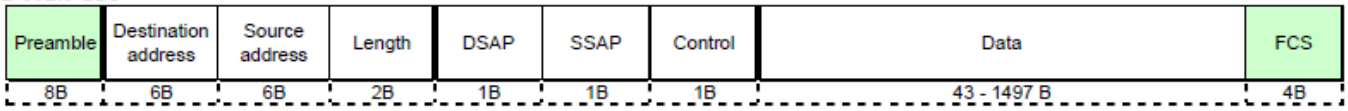
Ethernet II



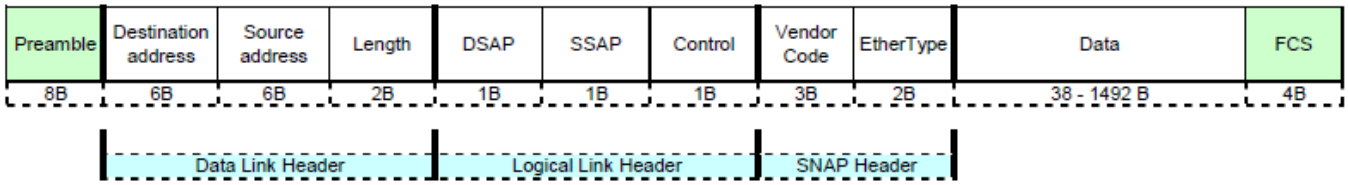
Novell 802.3 RAW (Novell proprietary)



IEEE 802.3 LLC



IEEE 802.3 LLC + SNAP



802.2 LLC Service Access Points (SAPs)

IEEE SAPs

Hex	Dec	Function
00	0	Null SAP
02	2	LLC Sublayer Management / Individual
03	3	LLC Sublayer Management / Group
06	6	IP (DoD Internet Protocol)
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

EtherType values

google 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	2049	X.75 Internet
0805	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

0 1 2 3 4 5 6 7 8 9 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3
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
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; minimum value = 8)

Checksum
(Covers pseudo-header and entire UDP datagram)

ARP

Bit Number

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

Hardware Address Type		Protocol Address Type
H/w Addr Len	Prot. Addr Len	Operation
Source Hardware Address		
Source Hardware Addr (cont.)		Source Protocol Address
Source Protocol 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

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

ID.							
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

Opcode
0 Standard query (QUERY)
1 Inverse query (IQUERY)
2 Server status request (STATUS)

AA
(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
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)

ARCOUNT
(No. of resource records in Additional Information section.

TCP/IP and tcpdump

Pocket Reference Guide

SANS Institute
incidents@sans.org
+1 317.580.9756
http://www.sans.org
http://www.incidents.org

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.
```

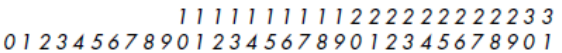
Acronyms

AH	Authentication Header (RFC 2402)	ISAKMP	Internet Security Association & Key Management Protocol (RFC 2408)
ARP	Address Resolution Protocol (RFC 826)	L2TP	Layer 2 Tunneling Protocol (RFC 2661)
BGP	Border Gateway Protocol (RFC 1771)	NNTP	Network News Transfer Protocol (RFC 977)
CWR	Congestion Window Reduced (RFC 2481)	OSPF	Open Shortest Path First (RFC 1583)
DF	Don't Fragment bit (IP)	POP3	Post Office Protocol v3 (RFC 1460)
DHCP	Dynamic Host Configuration Protocol (RFC 2131)	RFC	Request for Comments
DNS	Domain Name System (RFC 1035)	RIP	Routing Information Protocol (RFC 2453)
ECN	Explicit Congestion Notification (RFC 3168)	LDAP	Lightweight Directory Access Protocol (RFC 2251)
EIGRP	Extended IGRP (Cisco)	SKIP	Simple Key-Management for Internet Protocols
ESP	Encapsulating Security Payload (RFC 2406)	SMTP	Simple Mail Transfer Protocol (RFC 821)
FTP	File Transfer Protocol (RFC 959)	SNMP	Simple Network Management Protocol (RFC 1157)
GRE	Generic Routing Encapsulation (RFC 2784)	SSH	Secure Shell
HTTP	Hypertext Transfer Protocol (RFC 1945)	SSL	Secure Sockets Layer (Netscape)
ICMP	Internet Control Message Protocol (RFC 792)	TCP	Transmission Control Protocol (RFC 793)
IGMP	Internet Group Management Protocol (RFC 2236)	TFTP	Trivial File Transfer Protocol (RFC 1350)
IGRP	Interior Gateway Routing Protocol (Cisco)	TOS	Type of Service field (IP)
IMAP	Internet Message Access Protocol (RFC 2060)	UDP	User Datagram Protocol (RFC 768)
IP	Internet Protocol (RFC 791)		

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

ICMP

Bit Number



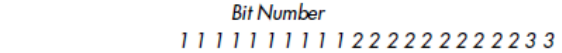
Type	Code	Checksum
Other message-specific information...		

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 Quench
 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
      0 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)

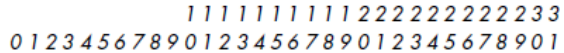
Bit Number



Type (8 or 0)	Code (0)	Checksum
Identifier		Sequence Number
Data...		

IP Header

Bit Number



Version	IHL	Type of Service	Total Length
Identification		Flags	Fragment Offset
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)	000
D	(1 = minimize delay)	0
T	(1 = maximize throughout)	0
R	(1 = maximize reliability)	0
C	(1 = minimize cost)	1 = ECN capable
x	(reserved and set to 0)	1 = congestion experienced

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)

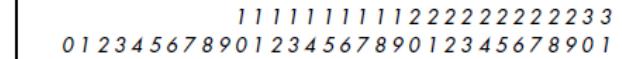
HOST_ID
0 Network value; broadcast (old)
255 Broadcast

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



Source Port			Destination Port
Sequence Number			
Acknowledgment Number			
Offset (Header Length)	Reserved	Flags	Window
Checksum			Urgent Pointer
Options (optional)			

TCP Header Contents

Common TCP Well-Known Server Ports

7	echo	110	pop3
19	chargen	111	sunrpc
20	ftp-data	119	nntp
21	ftp-control	139	netbios-ssn
22	ssh	143	imap
23	telnet	179	bgp
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

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

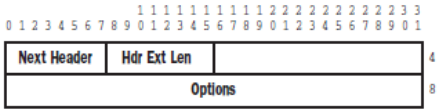
Urgent Pointer
Points to the sequence number of the byte following urgent data.

Options

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

Options Headers (Hop-by-Hop Options and Destination Options)

Bit Number

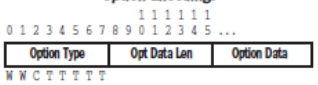


Next Header
8-bit identifier for the header immediately following this one. Uses the same codes as the main IPv6 header.

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.

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

Option Encoding:



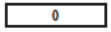
Option Type	8-bit Identifier
WW	indicate what to do if this option is not recognized:
00	skip this option and continue processing the header.
01	discard packet.
10	discard packet and send an ICMP Parameter Problem code 2 back to the source address pointing to the unrecognized Option Type.
11	discard packet and, if destination is not a multicast address, behave like type 10.
C	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
TTTTT	rest of the option type code

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

Option Data
Variable-length field.

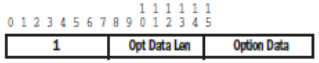
Options which must be implemented:

i) Pad1 option, special case:



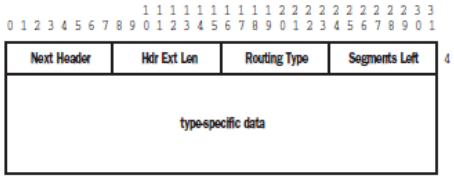
NOTE: no length or field values!

ii) PadN option:



Routing Header (similar to IPv4 LSRR and RR options)

Bit Number



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.

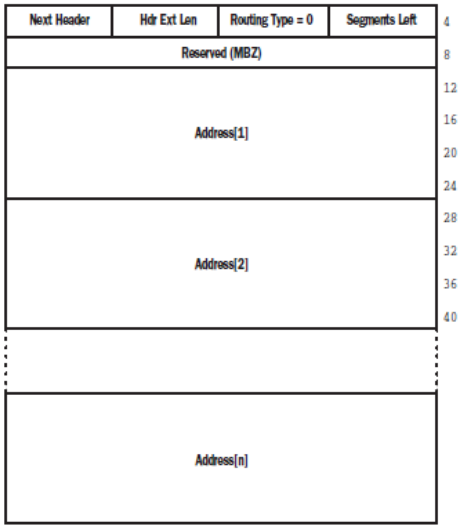
Routing Type
8-bit identifier

Segments Left
8-bit integer giving the number of listed intermediate nodes which still need to be visited.

type-specific data
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:

Type 0:



IPv6 TCP/IP and tcpdump

POCKET REFERENCE GUIDE

SANS INSTITUTE
incidents@sans.org • +1 317.580.9756 • http://www.sans.org • http://www.incidents.org

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.
```

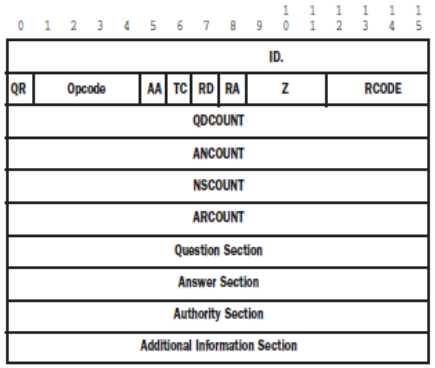
Acronyms

AH	Authentication Header (RFC 2402)	ISAKMP	Internet Security Association & Key Management Protocol (RFC 2408)
ARP	Address Resolution Protocol (RFC 826)	L2TP	Layer 2 Tunneling Protocol (RFC 2661)
BGP	Border Gateway Protocol (RFC 1771)	NNTP	Network News Transfer Protocol (RFC 977)
CWR	Congestion Window Reduced (RFC 2481)	OSPF	Open Shortest Path First (RFC 1583)
DF	Don't Fragment bit (IP)	POP3	Post Office Protocol v3 (RFC 1460)
DHCP	Dynamic Host Configuration Protocol (RFC 2131)	RFC	Request for Comments
DNS	Domain Name System (RFC 1035)	RIP	Routing Information Protocol (RFC 2453)
ECN	Explicit Congestion Notification (RFC 3168)	LDAP	Lightweight Directory Access Protocol (RFC 2251)
EIGRP	Extended IGRP (Cisco)	SKIP	Simple Key-Management for Internet Protocols
ESP	Encapsulating Security Payload (RFC 2406)	SMTP	Simple Mail Transfer Protocol (RFC 821)
FTP	File Transfer Protocol (RFC 959)	SNMP	Simple Network Management Protocol (RFC 1157)
GRE	Generic Routing Encapsulation (RFC 2784)	SSH	Secure Shell
HTTP	Hypertext Transfer Protocol (RFC 1945)	SSL	Secure Sockets Layer (Netscape)
ICMP	Internet Control Message Protocol (RFC 792)	TCP	Transmission Control Protocol (RFC 793)
IGMP	Internet Group Management Protocol (RFC 2236)	TFTP	Trivial File Transfer Protocol (RFC 1350)
IGRP	Interior Gateway Routing Protocol (Cisco)	TOS	Type of Service field (IP)
IMAP	Internet Message Access Protocol (RFC 2060)	UDP	User Datagram Protocol (RFC 768)
IP	Internet Protocol (RFC 791)		

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

DNS

Bit Number



Query/Response
0 Query
1 Response

Opcode
0 Standard query (QUERY)
1 Inverse query (IQUERY)
2 Server status request (STATUS)

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

QDCOUNT
(No. of entries in Question section)

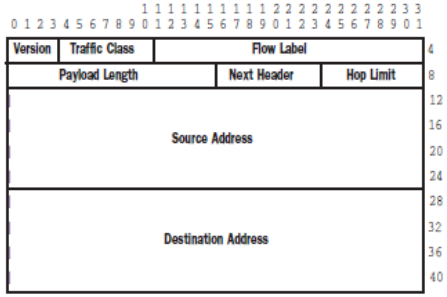
ANCOUNT
(No. of resource records in Answer section)

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

ARCOUNT
(No. of resource records in Additional Information section.

IPv6 Header

Bit Number



Version
4-bit 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:

0	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	UDP

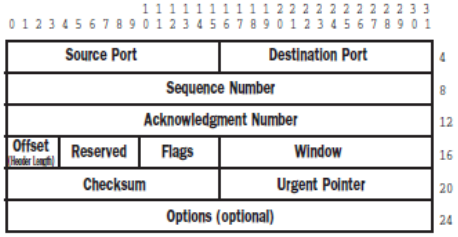
Hop Limit
8-bit unsigned integer. Decremented by 1 by each node that forwards the packet. The packet is discarded if Hop Limit is decremented to zero.

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



Common TCP Well-Known Server Ports

7	echo	110	pop3
19	chargen	111	sunrpc
20	ftp-data	119	nntp
21	ftp-control	139	netbios-ssn
22	ssh	143	imap
23	telnet	179	bgp
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

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

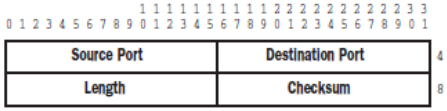
Urgent Pointer
Points to the sequence number of the byte following urgent data.

Options

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

UDP Header

Bit Number



Common UDP Well-Known Server Ports

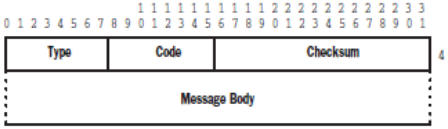
7	echo	138	netbios-dgm
19	chargen	161	snmp
37	time	162	snmp-trap
53	domain	500	isakmp
67	bootps (DHCP)	514	syslog
68	bootpc (DHCP)	520	rip
69	tftp	33434	traceroute
137	netbios-ns		

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

Checksum
(Covers pseudo-header and entire UDP datagram)

ICMPv6 (header type 58)

Bit Number

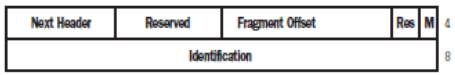


Type	Code	
1	0	no route to destination
	1	communication administratively prohibited
	2	(not assigned)
	3	address unreachable
	4	port unreachable
2	0	packet too big message, message body contains MTU of next hop link.
3	0	hop limit exceeded in transit
	1	fragment reassembly time exceeded
4	0	erroneous header field encountered
	1	unrecognized "Next Header" type encountered
	2	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
8-bit identifier for the header immediately following this one. Uses the same codes as the main IPv6 header.

Reserved
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].

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

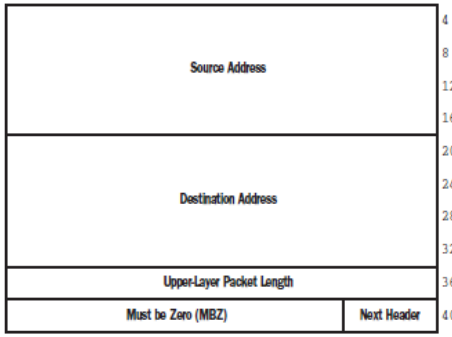
M flag
1 = more fragments; 0 = last fragment.

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



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