IPv4 Packet Header

0	4	8	16	19	24	31
Version	IHL	Type of Service		Total Length		
Identification			Flags	Fragment Offset		
Time to Live		Protocol	Header Checksum			
Source IP Address						
Destination IP Address						
Options					Padding	

- **Protocol:** specifies the upper-layer protocol
  - E.g., TCP (Protocol = 6), UDP (17), ICMP (1), and OSPF (89)
- **Header Checksum:** verifies the integrity of the IP header
- **Source IP Address and Destination IP Address:** contain the IP addresses of the source and destination hosts

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IPv4 Packet Header

0	4	8	16	19	24	31
Version	IHL	Type of Service		Total Length		
Identification			Flags	Fragment Offset		
Time to Live		Protocol	Header Checksum			
Source IP Address						
Destination IP Address						
Options					Padding	

- **TTL (Time to Live):** number of hops packet is allowed to traverse in the network
  - Each router along the path to the destination decrements this value by one
  - If the value reaches zero before the packet reaches the destination, the router discards the packet and sends an error message back to the source

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IPv4 Packet Header

0	4	8	16	19	24	31
Version	IHL	Type of Service	Total Length			
Identification			Flags	Fragment Offset		
Time to Live		Protocol	Header Checksum			
Source IP Address						
Destination IP Address						
Options					Padding	

- **Version:** IP version is 4
- **IHL (Internet Header Length):** length of the header (in 32-bit words)
- **ToS (Type of Service):** priority of packet at each router
- **Total Length:** length of the IP packet (in bytes) including header and data, maximum length is $2^{16} - 1 = 65535$ bytes

IPv4 Packet Header

0	4	8	16	19	24	31
Version	IHL	Type of Service	Total Length			
Identification			Flags	Fragment Offset		
Time to Live		Protocol	Header Checksum			
Source IP Address						
Destination IP Address						
Options					Padding	

- **Identification** identifies a particular IP packet
- **Flags** (Reserved bit, DF bit: don't fragment, MF bit: more fragment)
- **Fragment Offset** (in unit of 8 bytes) identifies the location of a fragment within an IP packet

IPv4 Packet Header

0	4	8		16	19	24	31
Version	IHL	Type of Service		Total Length			
Identification				Flags	Fragment Offset		
Time to Live		Protocol		Header Checksum			
Source IP Address							
Destination IP Address							
Options						Padding	

- **Options:** variable-length field (up to 40 bytes), which allows packet to request special features such as security level, route to be taken by the packet, and timestamp at each router
- **Padding:** used to make the IP packet header a multiple of 32-bit words

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Comparison of IPv4 and IPv6 Packet Headers
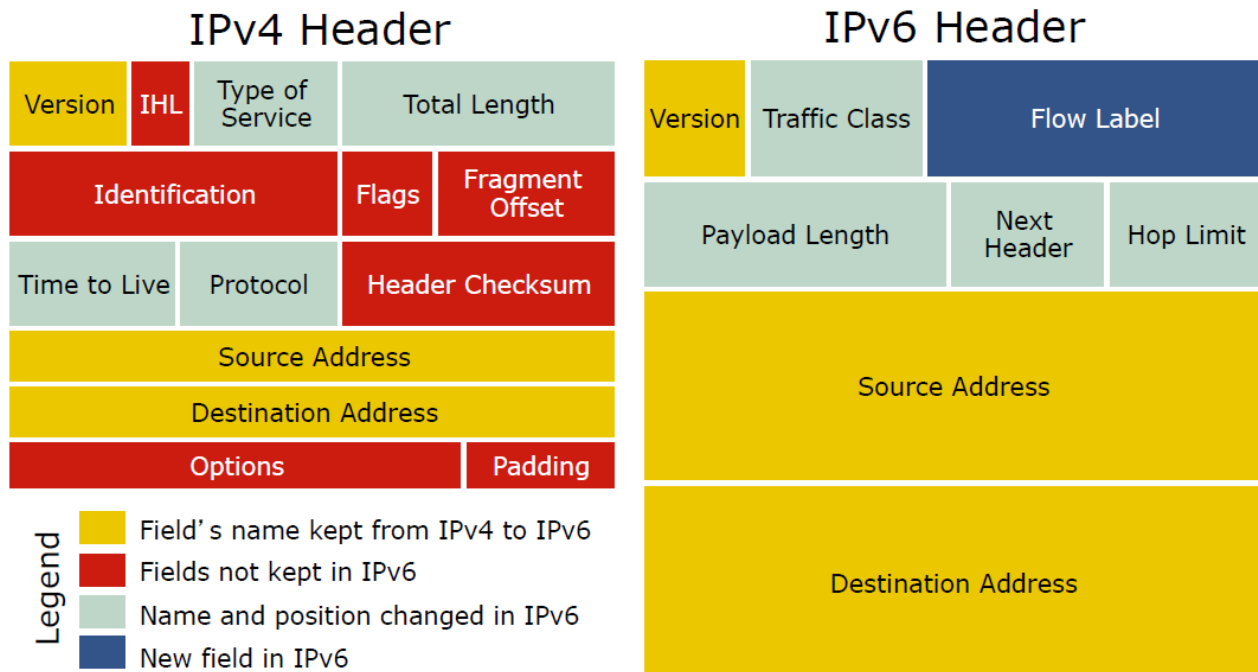
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Properties

Name:	Ethernet 3
Description:	Intel(R) Ethernet Connection I217-LM
Physical address (MAC):	98:90:96:d9:d0:b0
Status:	Operational
Maximum transmission unit:	1500
Link speed (Receive/Transmit):	1000/1000 (Mbps)
DHCP enabled:	Yes
DHCP servers:	10.10.67.166
DHCP lease obtained:	Tuesday, March 19, 2024 8:50:23 AM
DHCP lease expires:	Tuesday, March 19, 2024 9:50:23 AM
IPv4 address:	10.24.101.131/22
IPv6 address:	
Default gateway:	10.24.103.254
DNS servers:	129.186.78.200, 129.186.140.200, 129.186.142.200, 129.186.1.200
DNS domain name:	ece.iastate.edu
DNS connection suffix:	ece.iastate.edu
DNS search suffix list:	
Network name:	iastate.edu
Network category:	Domain
Connectivity (IPv4/IPv6):	Connected to Internet / Connected to unknown network

Handwritten annotations:

Dell

98
100/1000
↑↑ Single/Group
Global/local

✗

} $T = 1$ hour

0000|0|0 0001|000 0||00|0| |0000v||
/22 ←|→

Subnet Addr:
10.24.100.0/22
Range:
10.24.100.1
~ 10.24.103.254
Directed broadcast:
10.24.103.255

Handwritten:

TCP is to provide   end-to-end   service over IP.
                    connection-oriented
                    reliable
                    byte-stream

Ⓐ —— Internet —— Ⓑ

1. TCP ACK

	0	4	8	12	16	20	24	28	32

byte index {

Source Port	Destination Port

Sequence Number : *position of the 1st byte of segment in the byte stream*

Acknowledgment Number : *Cumulative Ack*

Data Offset	Reserved	Control Bits	Window

Checksum	Urgent Pointer

Option-Kind #1	Option-Length #1	Option-Data #1

Option-Kind #N	Option-Length #N	
	Option-Data #N	Padding

Data

0		3			6
Urgent Bit (URG)	Acknowl-edgment Bit (ACK)	Push Bit (PSH)	Reset Bit (RST)	Synch-ronize Bit (SYN)	Finish Bit (FIN)

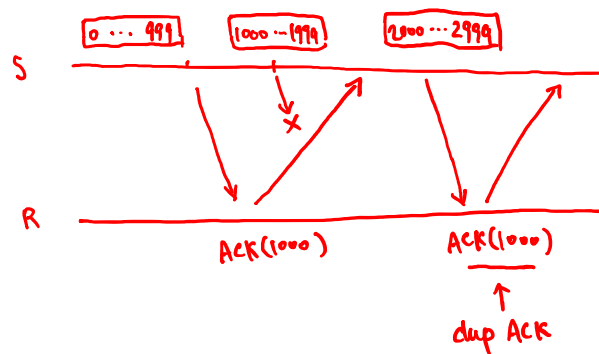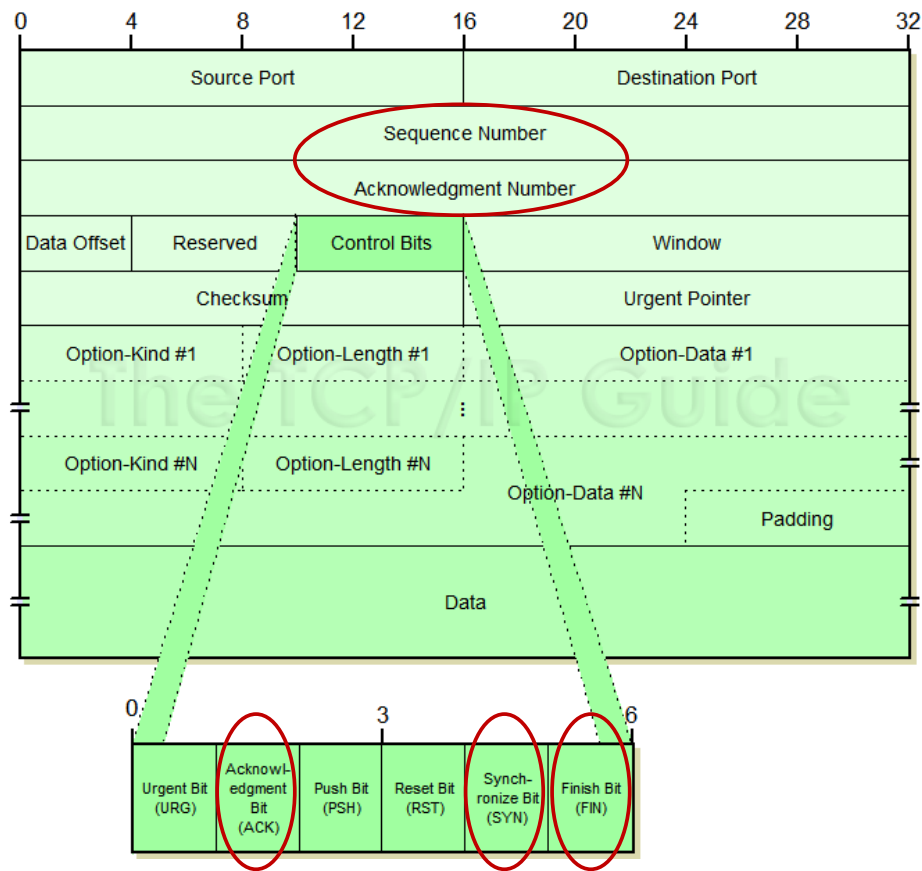*Cpr E 489 -- D.Q.*

✥ TCP ACK

➡ Acknowledgment Number: index of the next byte which the receiver expects to receive, NOT index of the next datagram to be received

• This is because TCP segments may have variable lengths and retransmitted TCP segment can include more data than the original

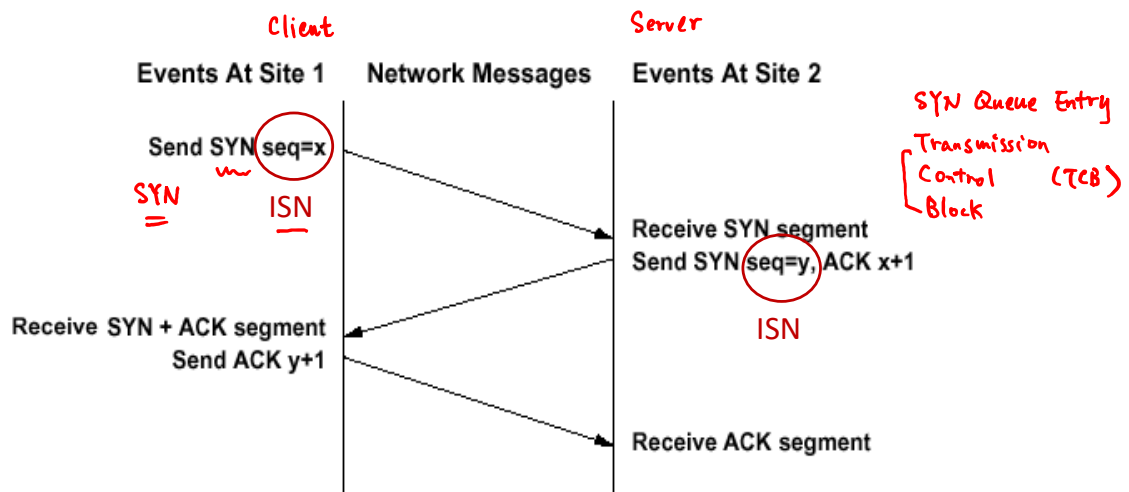➡ TCP ACK is cumulative

TCP uses ∧ SR ARQ.
special version

– no NAK
– relies on dup ACK

S [0 ··· 999] [1000 ··· 1999] [2000 ··· 2999]

R ACK(1000)   ACK(1000)
                  ↑
               dup ACK

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The TCP/IP Guide

0	4	8	12	16	20	24	28	32

Source Port / Destination Port
Sequence Number
Acknowledgment Number
Data Offset / Reserved / Control Bits / Window
Checksum / Urgent Pointer
Option-Kind #1 / Option-Length #1 / Option-Data #1
Option-Kind #N / Option-Length #N / Option-Data #N / Padding
Data

| Urgent Bit (URG) | Acknowl-edgment Bit (ACK) | Push Bit (PSH) | Reset Bit (RST) | Synch-ronize Bit (SYN) | Finish Bit (FIN) |

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⊕ TCP uses three-way handshake to establish a connection

Client   Server

Events At Site 1 **Network Messages** **Events At Site 2**

SYN Queue Entry

Transmission
Control   (TCB)
Block

Send SYN seq=x

SYN
=   ISN

Receive SYN segment
Send SYN seq=y, ACK x+1

ISN

Receive SYN + ACK segment
Send ACK y+1

Receive ACK segment

"SYN Flood Attack"

ISN: Initial Sequence Number (a byte index) ✱

"SYN Cookies"

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