

TCP/IP Protocol Architecture

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Overview

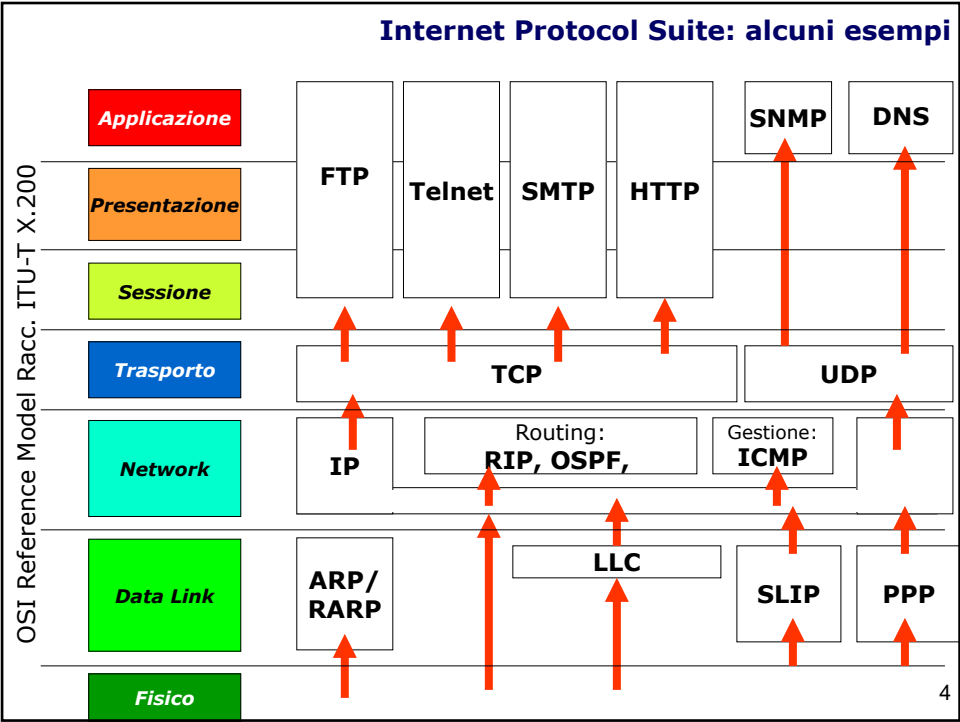
- Internet Protocol Suite
 - IPv4
 - ICMP
 - UDP
 - TCP

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INTERNET PROTOCOL SUITE

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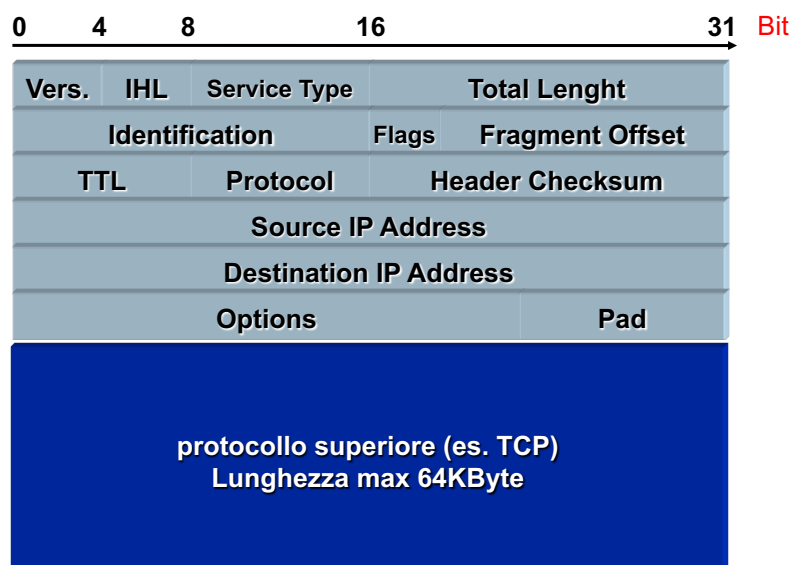


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IPV4

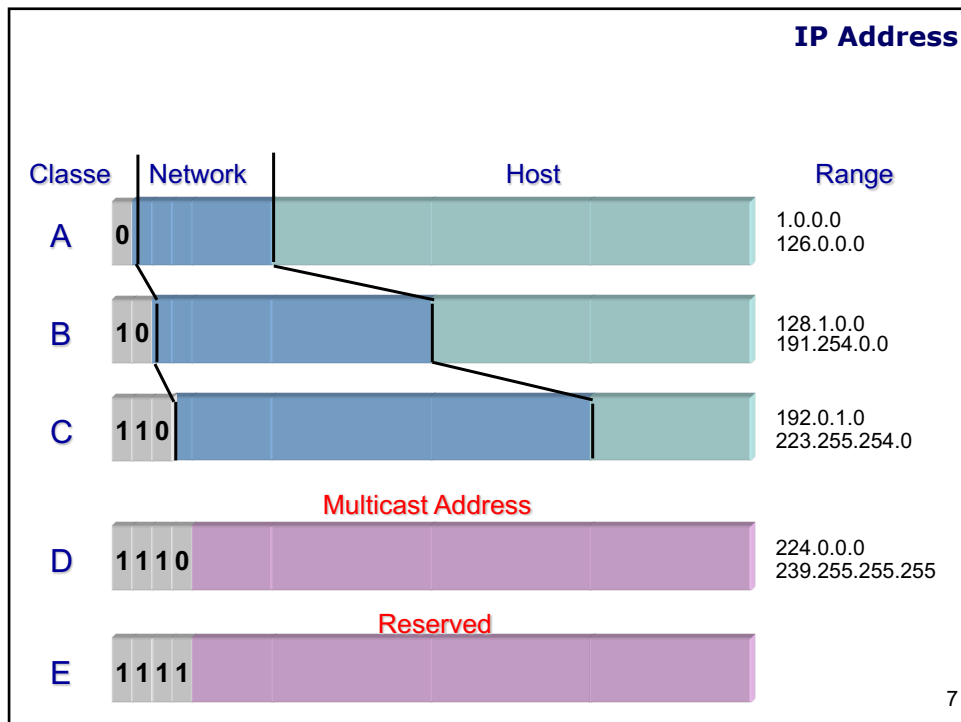
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Protocollo IP

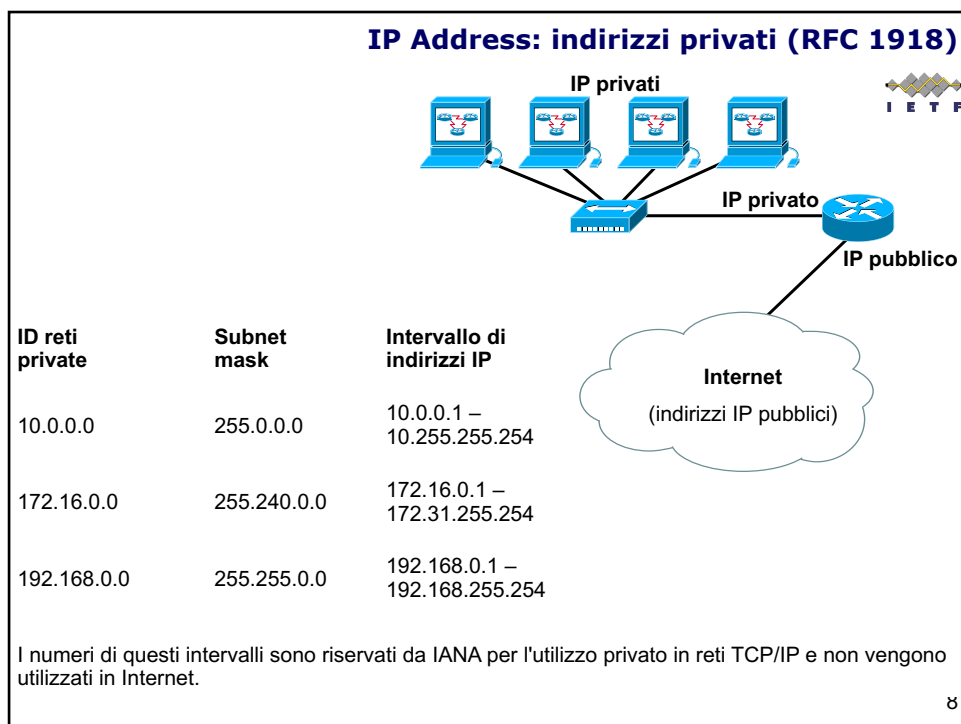


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Indirizzi speciali

Indirizzo	Significato	Utilizzo
0.0.0.0	Host stesso	usato durante il bootstrap (inizializzazione) della macchina
127.X.X.X	Loopback	testing



X.X.X.0	Rete	identifica una rete
X.X.X.255	Broadcast diretto	effettua il broadcast su tutta la rete
255.255.255.255	Broadcast limitato	effettua il broadcast sulla rete locale



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Indirizzi IP multicast

Alcuni indirizzi IP multicast

224.0.0.1	All Systems on this Subnet
224.0.0.2	All Routers on this Subnet
224.0.0.11	Mobile-Agents
224.0.0.12	DHCP Server / Relay Agent
224.0.0.18	VRRP
224.0.1.1	NTP - Network Time Protocol
224.0.1.6	NSS - Name Service Server
224.0.1.7	AUDIONEWS - Multicast
224.0.1.10	IETF-1-LOW-AUDIO
224.0.1.11	IETF-1-AUDIO
224.0.1.12	IETF-1-VIDEO
224.0.1.13	IETF-2-LOW-AUDIO
224.0.1.14	IETF-2-AUDIO
224.0.1.15	IETF-2-VIDEO
224.0.1.16	MUSIC-SERVICE

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II Subnetting

- Permette di ripartire il campo Host in Subnet / Host
- Necessita di una Subnet Mask
- La tecnica di subnetting è definita nell' RFC 950

IP Address classe A	10	.	0	.	0	.	1
	0 0 0 0 1 0 1 0 1						
Network	10	.	0	.	0	.	0
Host		.	0	.	0	.	1
Lunghezza del campo Network/Subnet							
Subnet Mask	1 1						0 0 0 0
	0 0 0 0 1 0 1 0 1						
Network/ Subnet	10	.	0	.	0	.	0
Host		.		.		.	1

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Versione e lunghezze del pacchetto

Vers.	IHL	Service Type	Total Length	
Identification		Flags	Fragment Offset	
TTL	Protocol	Header Checksum		
Source IP Address				
Destination IP Address				
Options			Pad	

Versione:

4 (IPv4); 6 (IPv6).

IHL (Internet Header Length):

lunghezza dell'header in blocchi di 32 bit (5 -15)

Total Lenght:

byte totali del pacchetto, inclusa l'intestazione (max 65535).

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Tipo di servizio

Vers.	IHL	Service Type	Total Lenght	
Identification		Flags	Fragment Offset	
TTL	Protocol	Header Checksum		
Source IP Address				
Destination IP Address				
Options			Pad	

Definisce la priorità e il tipo di routing, è composto da 2 sottocampi: Priorità e Routing

0	1	2	3	4	5	6	7
Priorità				Routing			
				D	T	R	C

Priorità:

111 - Network Control
 110 - Internetwork Control
 101 - CRITIC-ECP
 100 - Flash Override
 011 - Flash
 010 - Immediate
 001 - Priority
 000 - Routine

Flag di Routing:

D - bassi ritardi
 T - throughput alto
 R - percorso più affidabile
 C - percorso più economico

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Frammentazione dei pacchetti

Fornisce le informazioni necessarie per la frammentazione dei pacchetti durante l'attraversamento delle reti

Vers.	IHL	Service Type	Total Lenght	
Identification		Flags	Fragment Offset	
TTL		Protocol	Header Checksum	
Source IP Address				
Destination IP Address				
Options			Pad	

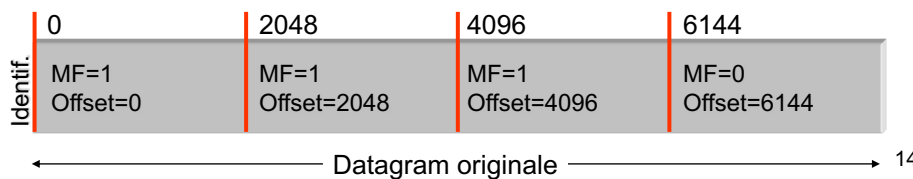
Identification:
numero di riferimento del datagram

Flags (3 bit):

bit 0: -
 bit 1: Don't Fragment
 bit 2: More Fragment

Fragment Offset:

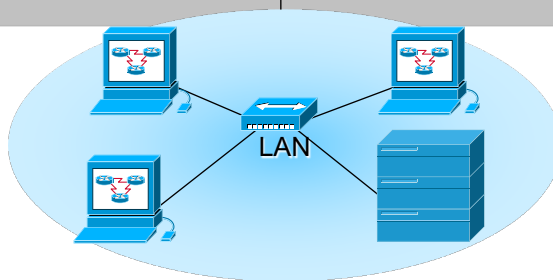
indirizzo del primo byte del pacchetto attuale rispetto alla collocazione nel pacchetto originale.



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Maximum Transfer Unit delle principali reti

Tipologia di rete	Dimensione massima della trama MTU (byte)
Token Ring (16 Mb/s)	17914
Token Ring (4 Mb/s)	4464
FDDI	4352
Ethernet	1500
X.25	576



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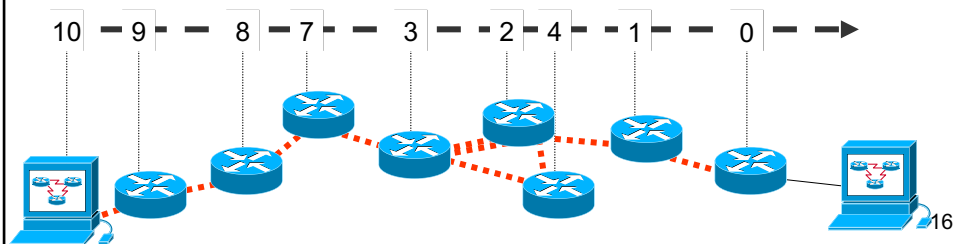
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TTL (Time to Live)

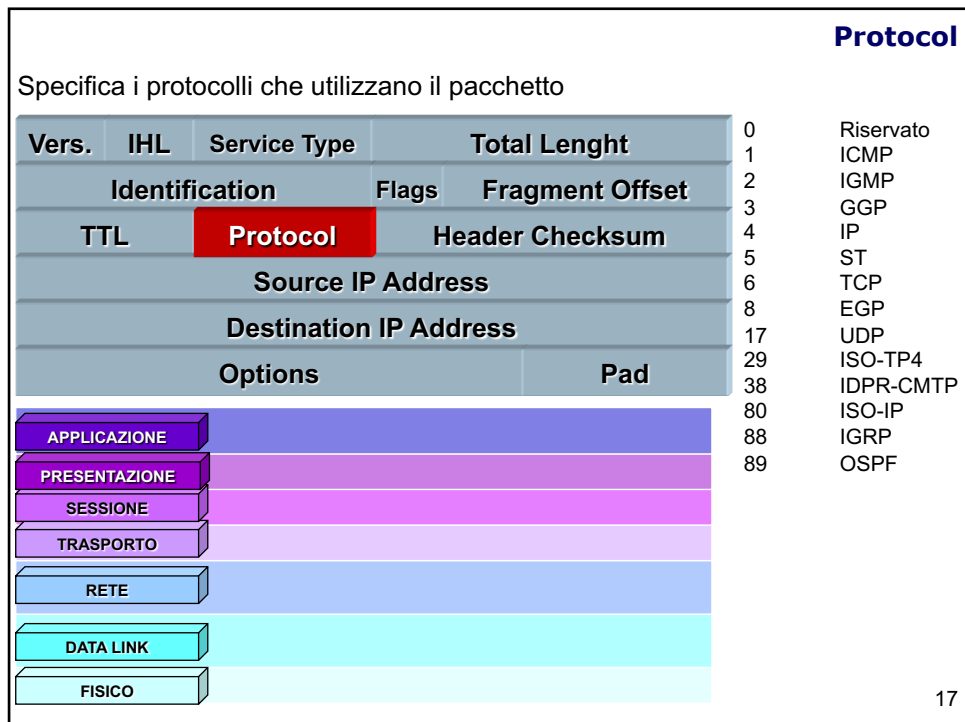
Definisce formalmente la vita massima di un datagramm espressa in hop

Vers.	IHL	Service Type	Total Lenght	
Identification			Flags	Fragment Offset
TTL		Protocol	Header Checksum	
Source IP Address				
Destination IP Address				
Options				Pad

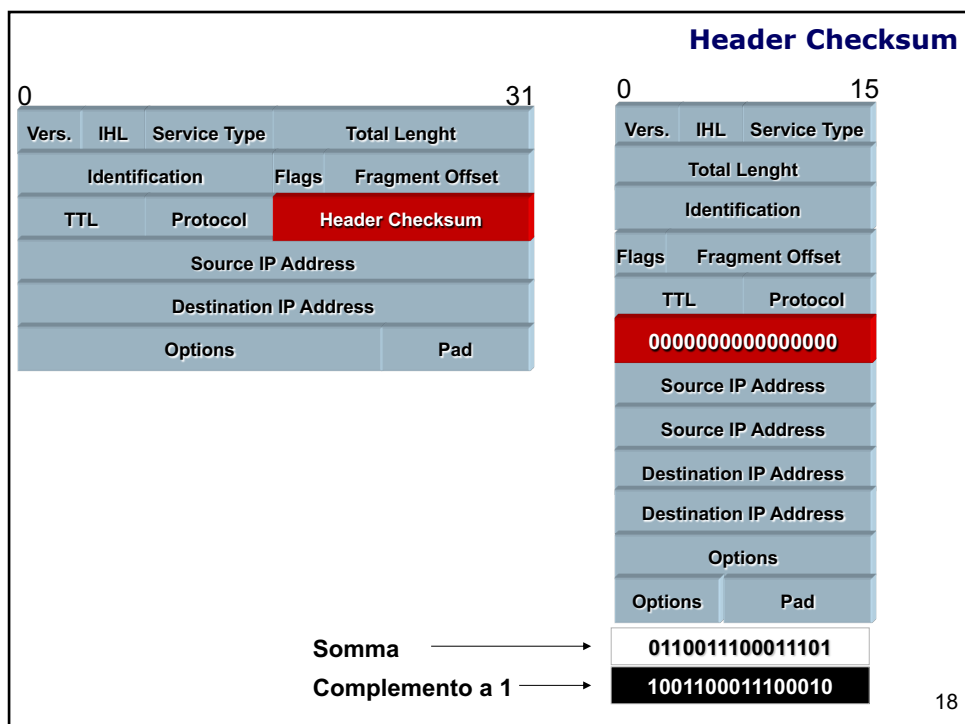
Contatore Time to Live



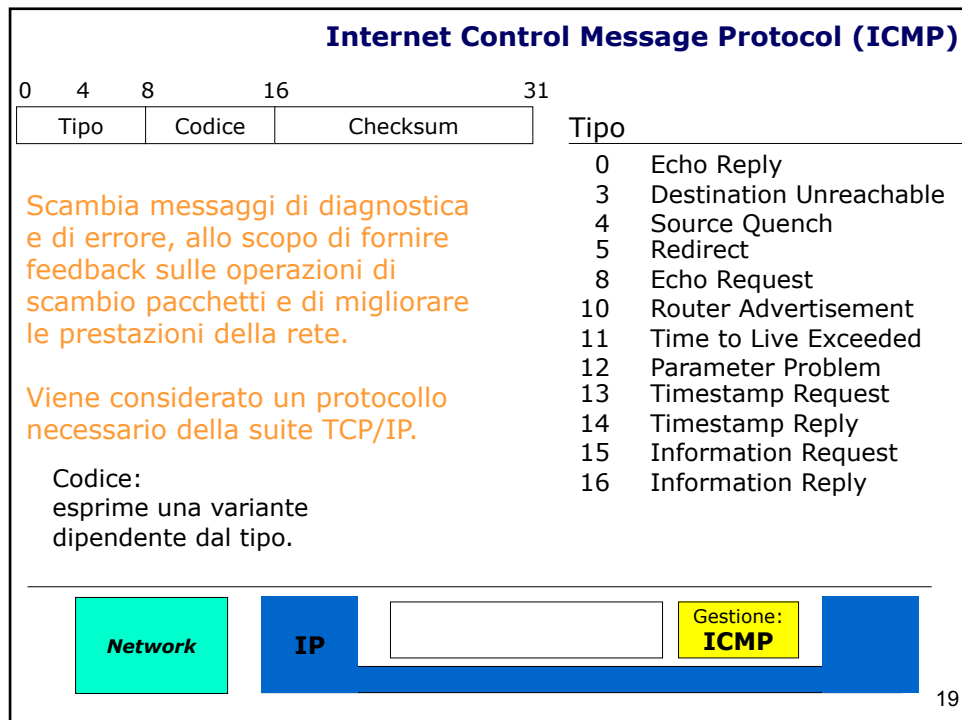
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					Messaggi Diagnostici	
0	4	8	16	31	Tipo	
Tipo		Codice		Checksum		
Non usato						
Vers.	IHL	Tipo Servizio		Lunghezza totale		
Identificazione			Flags	Offset frammento		
Tempo di vita		Protocollo		Checksum testata		
Indirizzo sorgente						
Indirizzo destinazione						
Opzioni				Pad		
Dati						
Dati						

0	Echo Reply
3	Destination Unreachable
4	Source Quench
5	Redirect
8	Echo Request
10	Router Advertisement
11	Time to Live Exceeded
12	Parameter Problem
13	Timestamp Request
14	Timestamp Reply
15	Information Request
16	Information Reply

Tipo 11: Codici		Tipo 3: Codici		Tipo 4: Codici	
0 - scaduto in transito		0 - rete irraggiungibile		0 - riduci di metà la	
1 - scaduto durante		1 - host irraggiungibile		frequenza di pacchetto	
riassemblaggio		2 - protocollo irraggiungibile			
		3 - porto irraggiungibile			
		4 - frammentazione necessaria ma non concessa			
		5 - fallimento del source routing			

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Ping

0	4	8	16	31	
Tipo	Codice	Checksum			<div style="color: green; font-weight: bold;">Tipo</div> <div style="color: green;">0 Echo Reply</div> <div style="color: blue;">3 Destination Unreachable</div> <div style="color: blue;">4 Source Quench</div> <div style="color: blue;">5 Redirect</div> <div style="color: green;">8 Echo Request</div> <div style="color: blue;">10 Router Advertisement</div> <div style="color: blue;">11 Time to Live Exceeded</div> <div style="color: blue;">12 Parameter Problem</div> <div style="color: blue;">13 Timestamp Request</div> <div style="color: blue;">14 Timestamp Reply</div> <div style="color: blue;">15 Information Request</div> <div style="color: blue;">16 Information Reply</div>
Identificatore		Numero sequenza			
Dati					

.....

PING ds.internic.net:

108 bytes from 198.45.45.10: icmp-seq=2.	time=173. ms
108 bytes from 198.45.45.10: icmp-seq=0.	time=5048. ms
108 bytes from 198.45.45.10: icmp-seq=1.	time=4410. ms
108 bytes from 198.45.45.10: icmp-seq=3.	time=2461. ms
108 bytes from 198.45.45.10: icmp-seq=8.	time=150. ms
108 bytes from 198.45.45.10: icmp-seq=10.	time=191. ms
108 bytes from 198.45.45.10: icmp-seq=11.	time=218. ms
108 bytes from 198.45.45.10: icmp-seq=12.	time=210. ms
108 bytes from 198.45.45.10: icmp-seq=13.	time=140. ms
108 bytes from 198.45.45.10: icmp-seq=14.	time=270. ms
108 bytes from 198.45.45.10: icmp-seq=15.	time=168. ms
108 bytes from 198.45.45.10: icmp-seq=16.	time=152. ms
108 bytes from 198.45.45.10: icmp-seq=17.	time=199. ms
108 bytes from 198.45.45.10: icmp-seq=18.	time=220. ms

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Traceroute

IP address	Sorg. Dest.		TTL
194.34.34.5	138,96,34,2	←	▶ 6
194.34.34.5	140,78,7,9	←	▶ 5
194.34.34.5	192,56,7,7	←	▶ 4
194.34.34.5	156,16,3,3	←	▶ 3
194.34.34.5	146,26,28,3	←	▶ 2
194.34.34.5	136,24,2,34	←	▶ 1

194.34.34.5

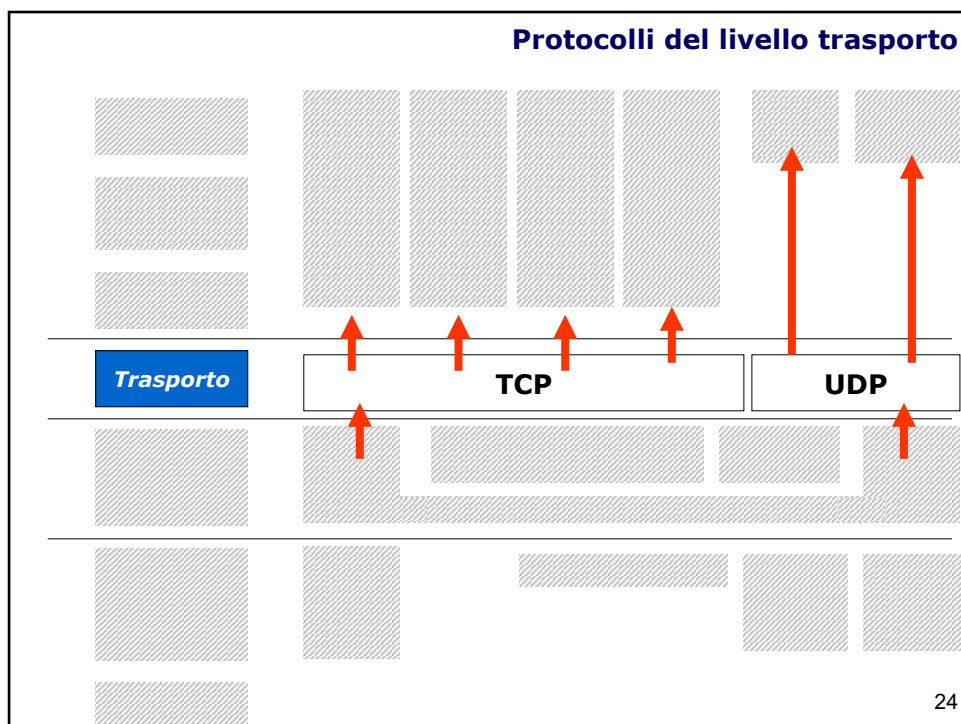
138.96.34.2

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TCP, UDP

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Il Protocollo TCP (Transport Control Protocol)

- TCP (Transport Control Protocol) è un protocollo di livello 4 (trasporto)
- Definito da RFC 1122/1123 ... e decine di altri!
- È un protocollo:
 - ✓ Full-duplex
 - ✓ Connection-oriented
 - ✓ Garantisce consegna affidabile ed in sequenza
 - ✓ Controllo velocità di emissione dei dati

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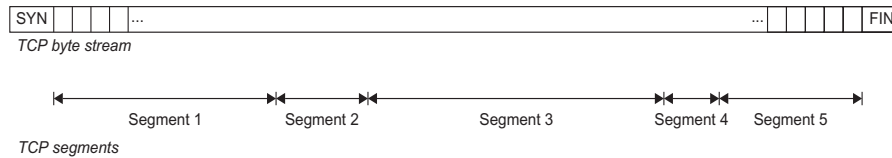
Il Protocollo TCP

- Ritrasmette se non riceve conferma di ricezione
- Esegue controllo di congestione end-to-end per evitare che la rete venga utilizzata oltre la sua capacità
- Esegue il controllo di flusso end-to-end perché un host veloce non saturi un host lento
- Frammenta (o raccoglie) l'informazione in segmenti di dimensione opportuna
- Mette in sequenza i datagram IP che arrivano fuori sequenza

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A Segmented TCP Stream

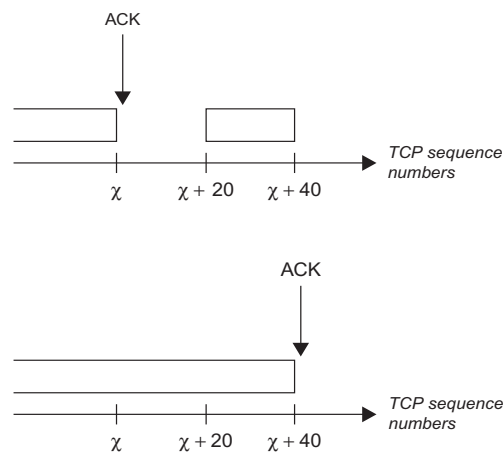


- Each byte in the TCP byte stream is assigned a sequence number.
- The stream is partitioned into segments that may be arbitrarily sized.
- Each segment is prepended with a TCP header and transmitted in separate IP packets.
- In theory, for each received segment the receiver produces an ACK. In practice, however, most TCP implementations send an ACK only on every other incoming segment to reduce ACK traffic.
- ACKs are also piggybacked on outgoing TCP segments.
 - The ACK contains the next sequence number expected in the continuous stream of bytes.
 - Thus, ACKs do not acknowledge the reception of any individual segment, but rather acknowledge the transmission of a continuous range of bytes.

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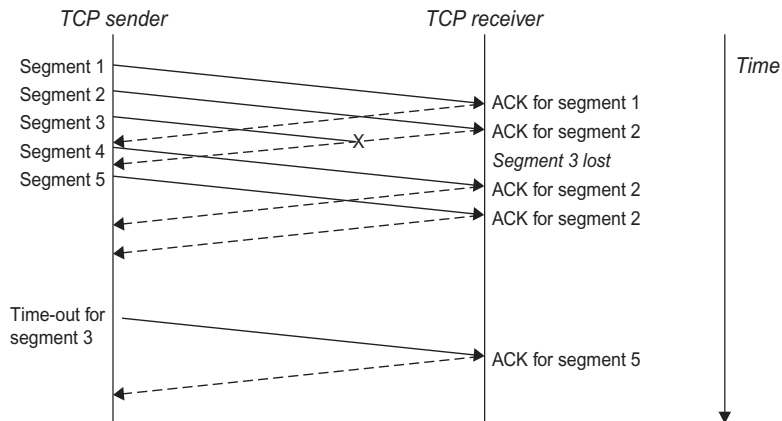
A TCP byte stream with a gap and a corresponding ACK



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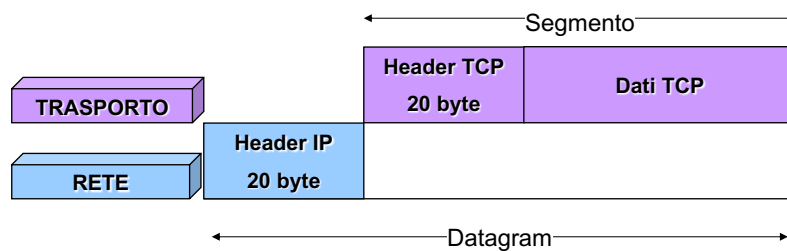
Loss of a TCP segment and the corresponding time-out



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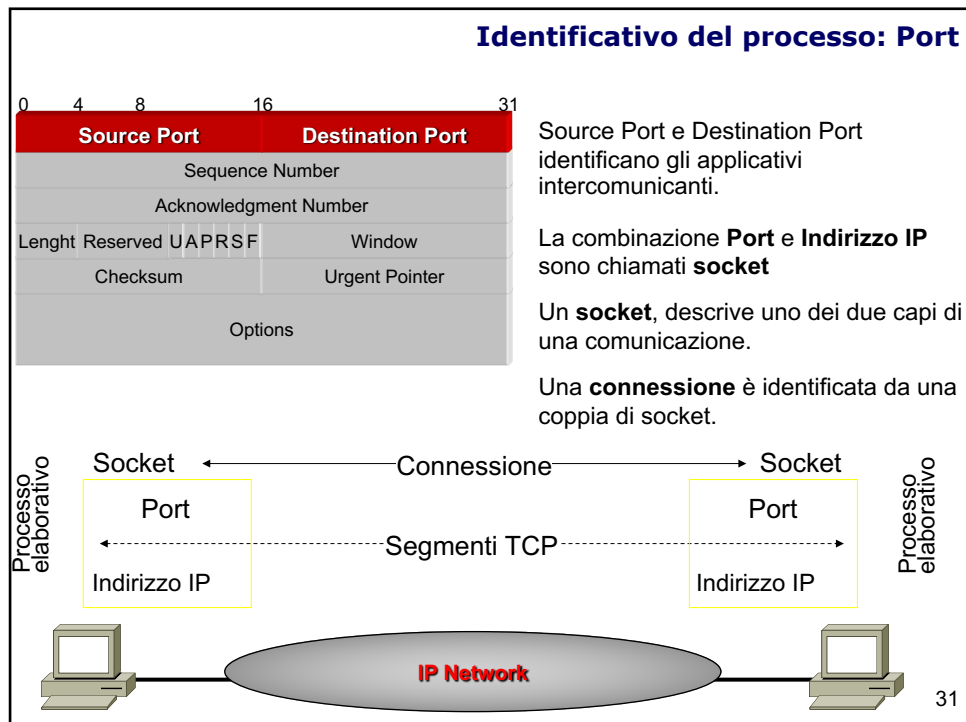
TCP: Caratteristiche e funzioni



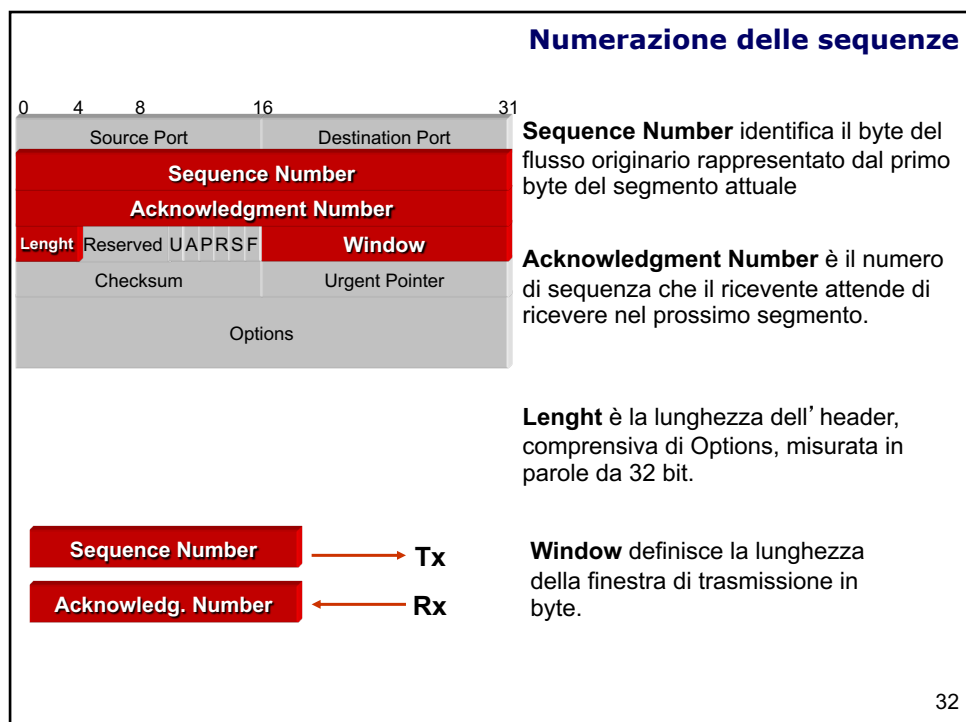
- Stabilisce comunicazioni connection oriented esenti da errori
- Suddivide i dati in segmenti
- Associa un time-out alla trasmissione
- Il segmento viene controllato con algoritmi di checksum
- I segmenti errati vengono scartati senza messaggi d'errore
- I segmenti ricevuti vengono riassemblati nell'ordine giusto (se frammentati in transito)
- I segmenti duplicati vengono scartati
- Viene fornito un servizio di controllo flusso
- Non vengono interpretati i messaggi contenuti nel segmento; sarà compito del livello applicativo.

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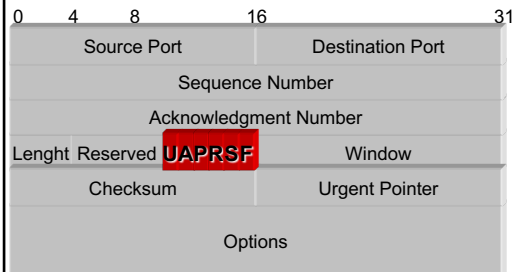


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Flags



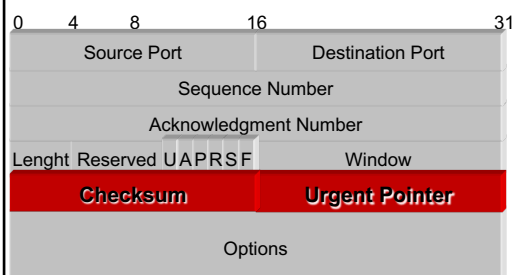
Flag:

- URG - L' Urgent Pointer è valido
- ACK - L' Acknowledgment Number è valido
- PSH - Il ricevente deve passare queste informazioni all'applicativo nel più breve tempo possibile
- RST - Reset di connessione
- SYN - Sincronizzare i numeri di sequenza per iniziare una connessione
- FIN - Il trasmittente ha finito l'invio dei dati

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Controlli



Checksum:

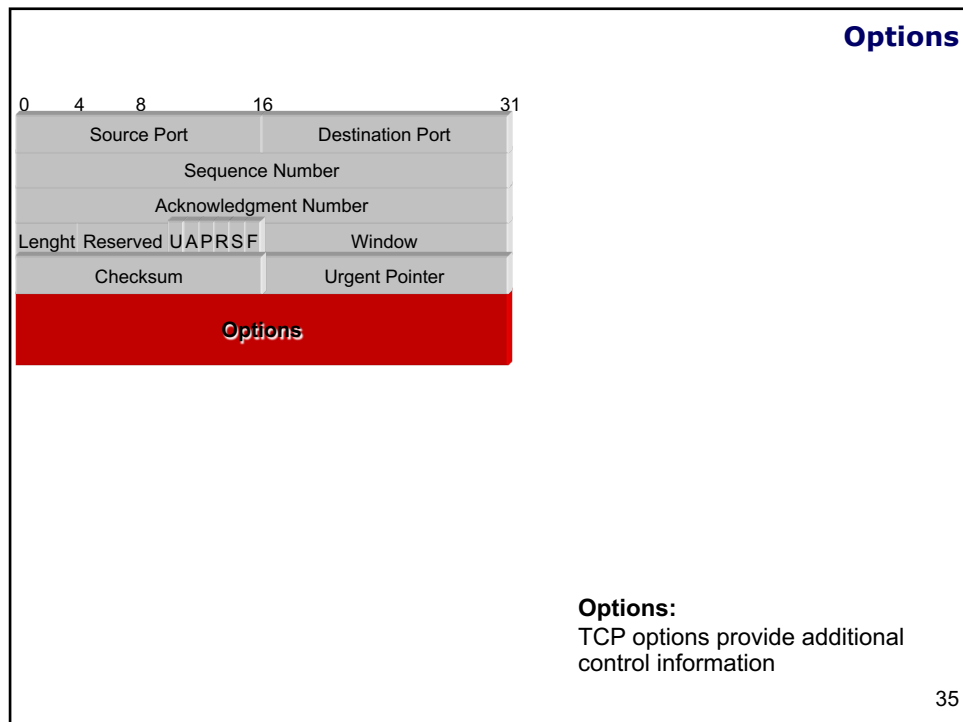
controllo d' errore calcolato sull'intero segmento.

Urgent Pointer:

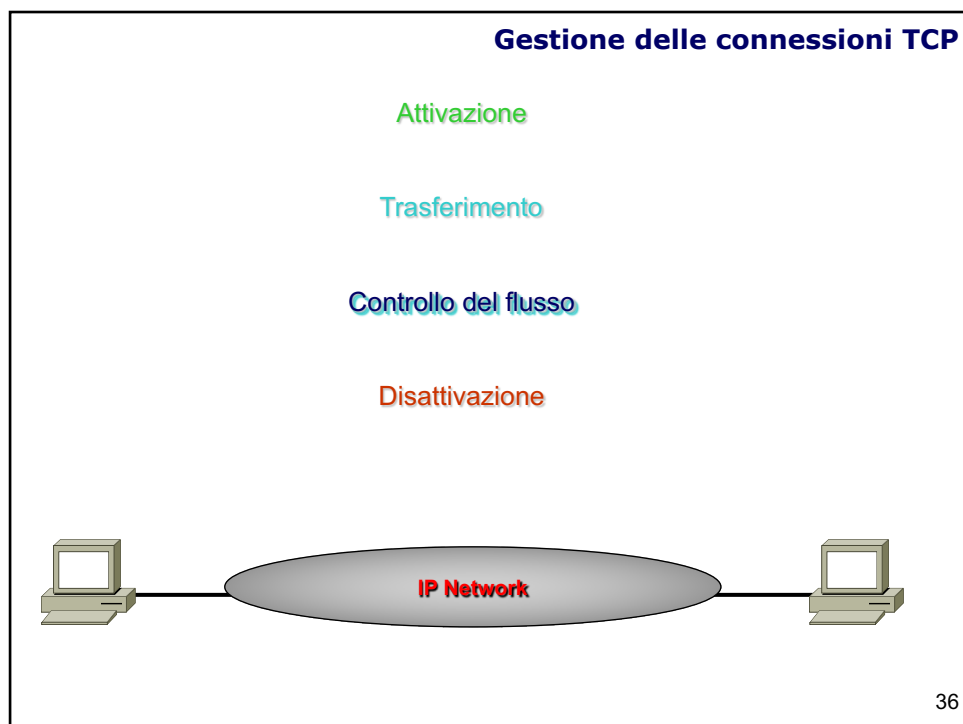
offset da aggiungere al Numero di Sequenza per ottenere il numero di sequenza dell'ultimo byte di dati urgenti.

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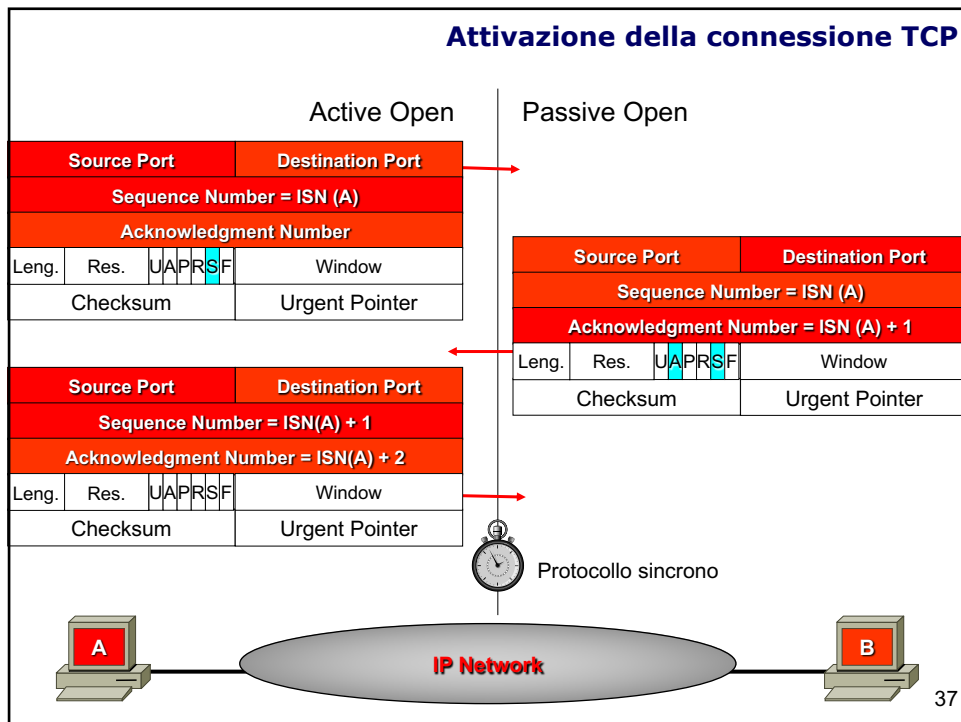
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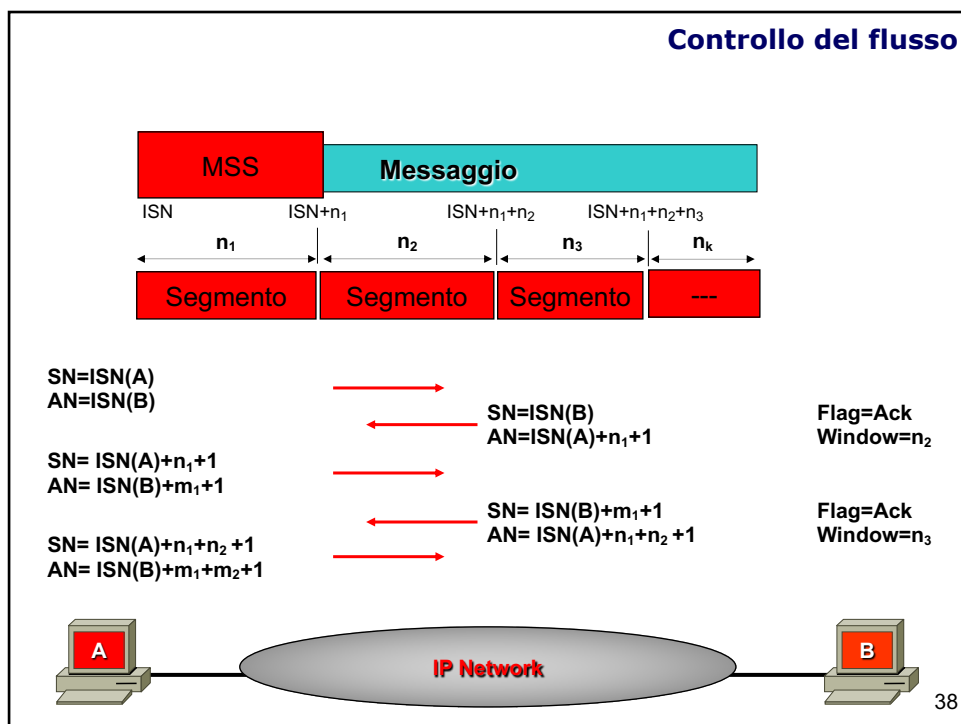
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Maximum Segment Size

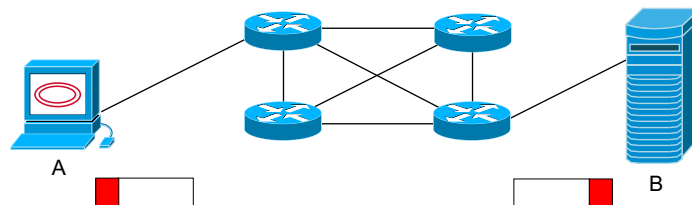
```

Frame 257 (62 bytes on wire, 62 bytes captured)
Ethernet II, Src: 00:02:3f:34:60:3b, Dst: 00:50:54:ff:3a:d3
Internet Protocol, Src Addr: 192.168.0.92 (192.168.0.92), Dst Addr: 205.188.212.121 (205.188.212.121)
Transmission Control Protocol, Src Port: 2450 (2450), Dst Port: 63843 (63843), Seq: 3941641389, Ack: 0, Len: 0
  Source port: 2450 (2450)
  Destination port: 63843 (63843)
  Sequence number: 3941641389
  Header length: 28 bytes
  Flags: 0x0000 (syn)
  Window size: 16384
  Checksum: 0x4550 (correct)
  Options: (8 bytes)
    Maximum segment size: 1460 bytes
    NOP
    NOP
    SACK permitted

Frame 259 (62 bytes on wire, 62 bytes captured)
Ethernet II, Src: 00:50:54:ff:3a:d3, Dst: 00:02:3f:34:60:3b
Internet Protocol, Src Addr: 205.188.212.121 (205.188.212.121), Dst Addr: 192.168.0.92 (192.168.0.92)
Transmission Control Protocol, Src Port: 63843 (63843), Dst Port: 2450 (2450), Seq: 3627315610, Ack: 3941641390, Len: 0
  Source port: 63843 (63843)
  Destination port: 2450 (2450)
  Sequence number: 3627315610
  Acknowledgement number: 3941641390
  Header length: 28 bytes
  Flags: 0x0012 (syn, ack)
  Window size: 8520
  Checksum: 0x1a50 (correct)
  Options: (8 bytes)
    NOP
    NOP
    SACK permitted
    Maximum segment size: 1420 bytes
  
```

➤ Es. MSS=1420 bytes

MSS (Maximum Segment Size): valore massimo concordabile nel caso Ethernet = 1460 bytes
Definito col primo segmento (SYN) e confermato o variato dal ricevitore con segmento (SYN ACK)



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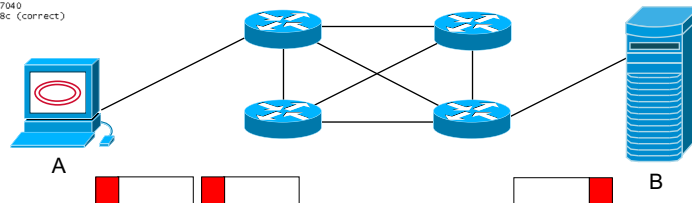
Controllo di flusso

```

Frame 262 (1474 bytes on wire, 1474 bytes captured)
Ethernet II, Src: 00:02:3f:34:60:3b, Dst: 00:50:54:ff:3a:d3
Internet Protocol, Src Addr: 205.188.212.121 (205.188.212.121), Dst Addr: 192.168.0.92 (192.168.0.92)
Transmission Control Protocol, Src Port: 63843 (63843), Dst Port: 2450 (2450), Seq: 3627315611, Ack: 3941641390, Len: 1420
  Source port: 63843 (63843)
  Destination port: 2450 (2450)
  Sequence number: 3627315611
  Next sequence number: 3627317031
  Acknowledgement number: 3941641390
  Header length: 20 bytes
  Flags: 0x0010 (ack)
  Window size: 8520
  Checksum: 0x217a (correct)
FTP Data

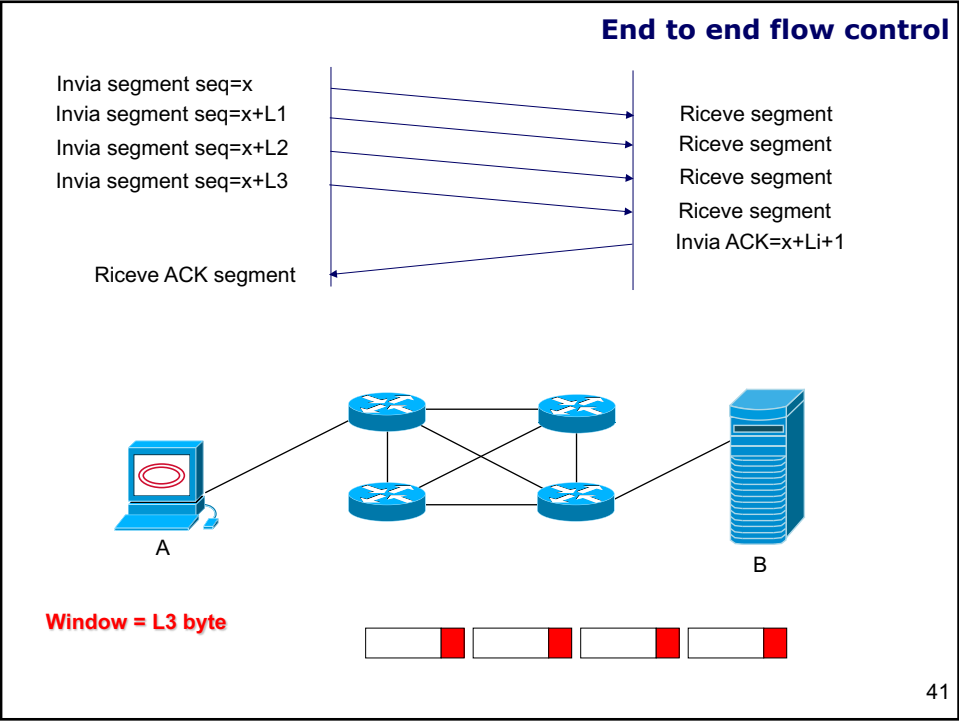
Frame 263 (1474 bytes on wire, 1474 bytes captured)
Ethernet II, Src: 00:50:54:ff:3a:d3, Dst: 00:02:3f:34:60:3b
Internet Protocol, Src Addr: 205.188.212.121 (205.188.212.121), Dst Addr: 192.168.0.92 (192.168.0.92)
Transmission Control Protocol, Src Port: 63843 (63843), Dst Port: 2450 (2450), Seq: 3627317031, Ack: 3941641390, Len: 1420
  Source port: 63843 (63843)
  Destination port: 2450 (2450)
  Sequence number: 3627317031
  Next sequence number: 3627318451
  Acknowledgement number: 3941641390
  Header length: 20 bytes
  Flags: 0x0018 (PSH, ACK)
  Window size: 8520
  Checksum: 0xb029 (correct)
FTP Data

Frame 264 (54 bytes on wire, 54 bytes captured)
Ethernet II, Src: 00:02:3f:34:60:3b, Dst: 00:50:54:ff:3a:d3
Internet Protocol, Src Addr: 192.168.0.92 (192.168.0.92), Dst Addr: 205.188.212.121 (205.188.212.121)
Transmission Control Protocol, Src Port: 2450 (2450), Dst Port: 63843 (63843), Seq: 3941641390, Ack: 3627318451, Len: 0
  Source port: 2450 (2450)
  Destination port: 63843 (63843)
  Sequence number: 3941641390
  Acknowledgement number: 3627318451
  Header length: 20 bytes
  Flags: 0x0010 (ack)
  Window size: 17040
  Checksum: 0x1a8c (correct)
  
```

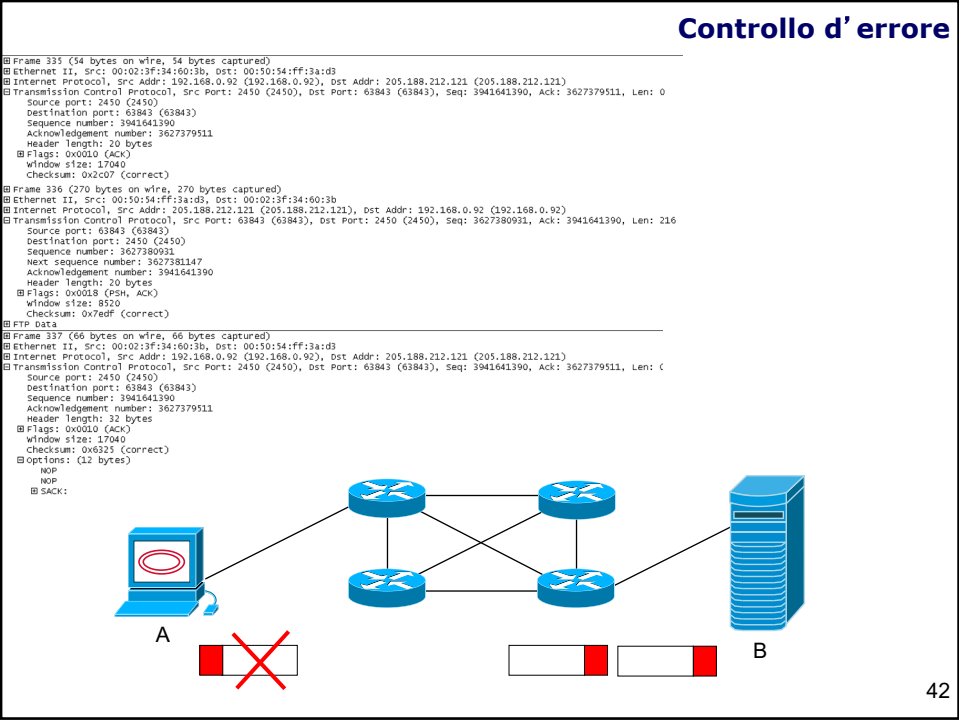


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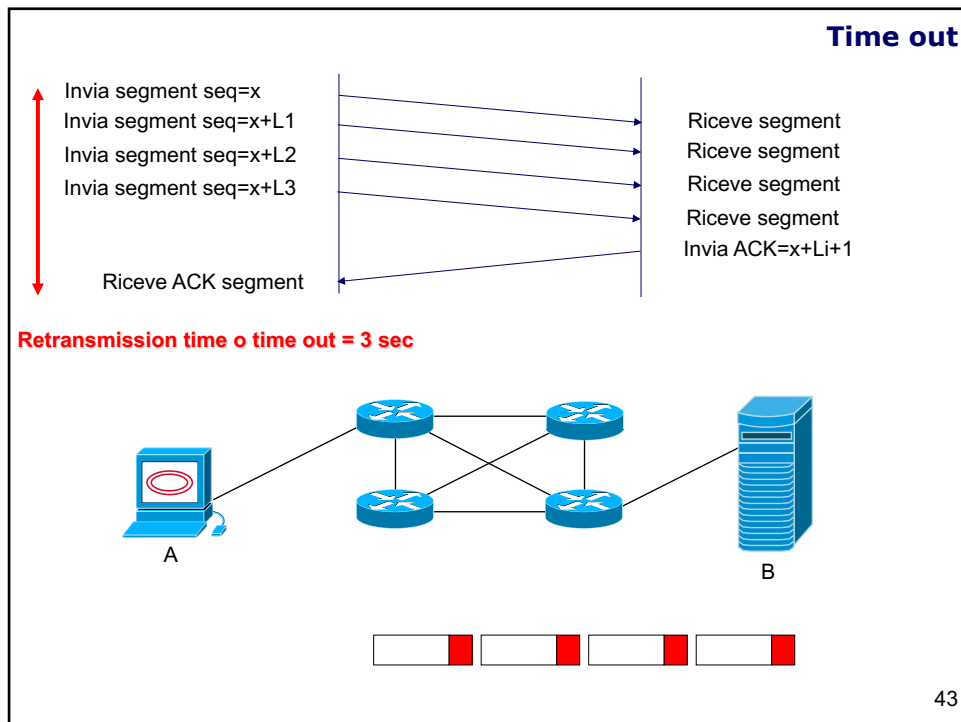
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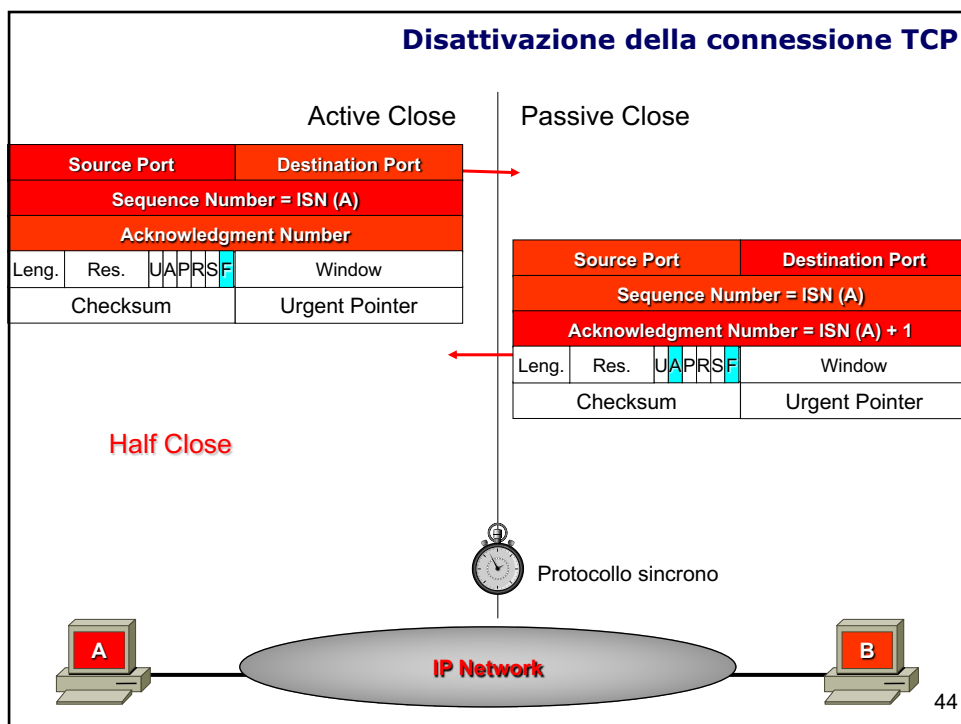
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Congestion Control

If flow control ignores that the buffer space will be overrun at the end points, the congestion control mechanisms try to prevent the overrun of router buffer space.

To achieve this TCP uses two separate methods:

- **Slow start:** Probes the available bandwidth when starting to send over a connection
- **Congestion avoidance:** Constantly adapts the sending rate to the perceived bandwidth of the path between the sender and the receiver

For smart object networks, which may have only limited amounts of data to send, TCP congestion control is rarely invoked

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Round-Trip Time Estimation

A critical factor of any reliable protocol is the **round-trip time estimation**, since the round-trip time determines the time to wait for an ACK before retransmitting a segment

- If the round-trip time estimate is much lower than the actual round-trip time of the connection, segments will be retransmitted before the original segment or its corresponding ACK has propagated through the network
- If the round-trip time estimation is too high, time-outs will be longer than necessary, thus reducing performance

TCP uses feedback provided by its acknowledgment mechanism to measure round-trip times

- Round-trip time measurements are taken once per window

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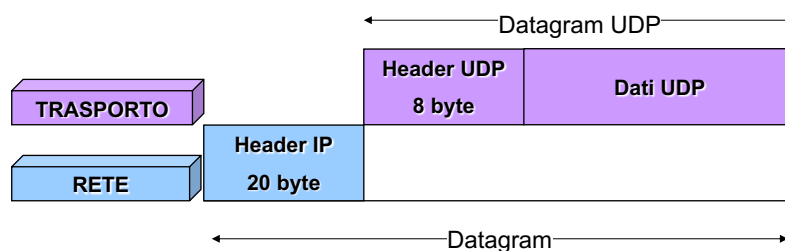
Il Protocollo UDP (User Datagram Protocol)

- UDP (User Datagram Protocol) permette alle applicazioni di un host l'invio di datagram ad altre applicazioni di un host remoto
- Definito da RFC-768 (1980)
- UDP fornisce un servizio di livello 4, ma:
 - ✓ Connectionless (pacchetti fuori sequenza)
 - ✓ Non affidabile (pacchetti persi)
 - ✓ Senza controllo di flusso (saturazione del ricevitore)

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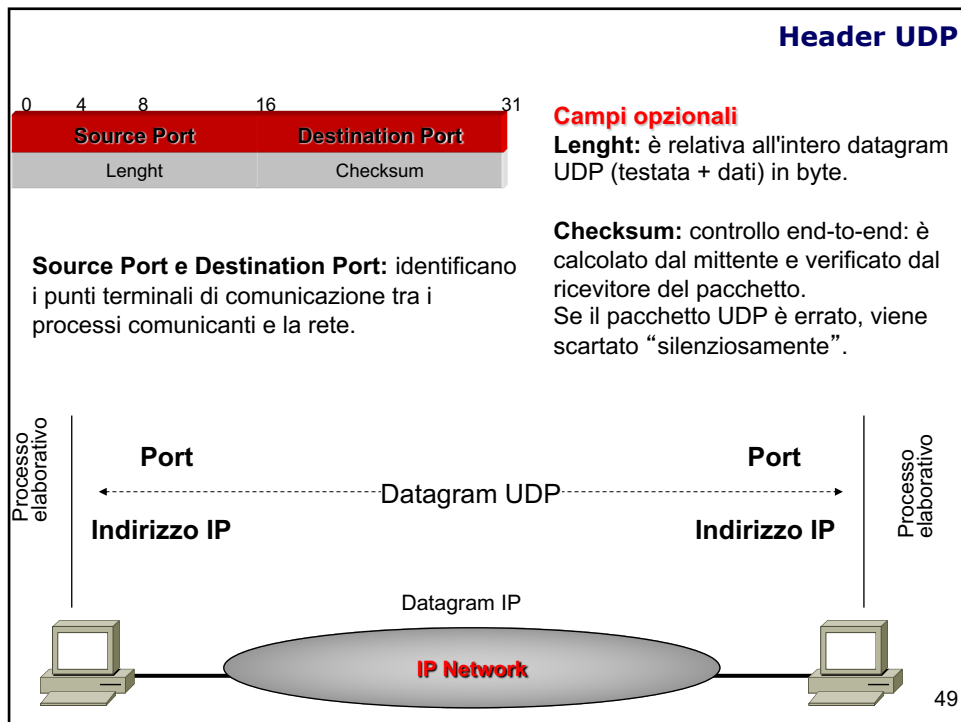
User Datagram Protocol (UDP)



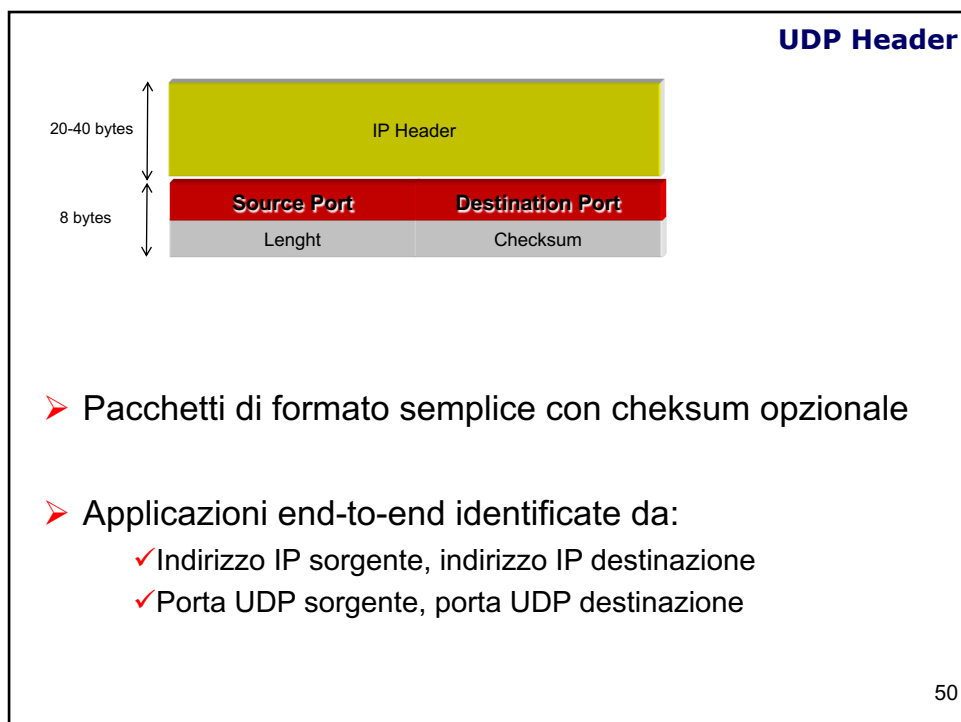
- Fornisce un servizio connection less inaffidabile
- I dati sono suddivisi in porzioni chiamate datagram UDP
- Non ci sono procedure di attivazione della connessione
- **Il datagram UDP viene controllato con algoritmi di checksum solo opzionalmente**
- **I segmenti errati vengono scartati senza messaggi d'errore**
- Non fornisce nessun servizio di controllo flusso
- Non vengono interpretati i messaggi contenuti nel segmento; sarà compito del livello applicativo.

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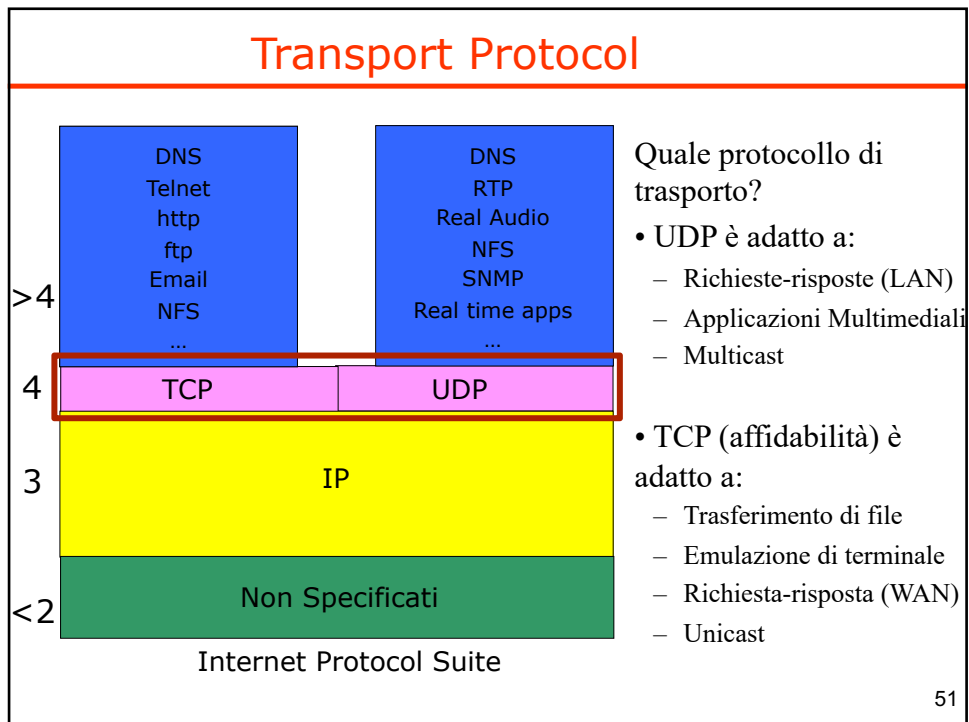
48



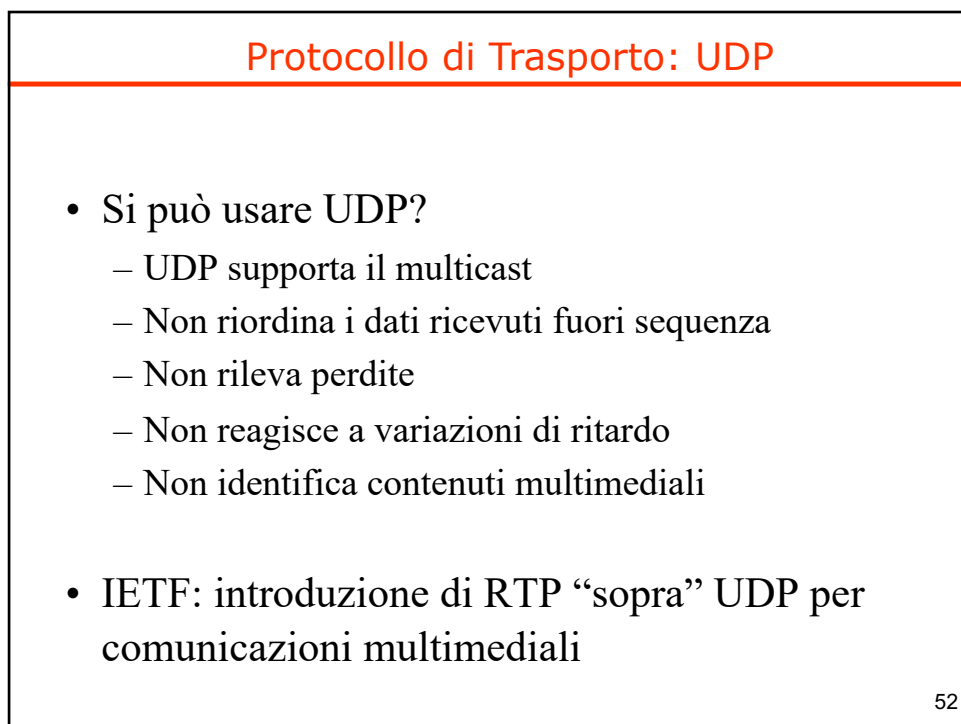
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Protocollo di Trasporto: TCP

- Si può usare TCP?
 - TCP offre un trasporto affidabile, ma le ritrasmissioni ed il controllo di flusso/congestione causano:
 - Ritardi in caso di perdita
 - Variazioni della banda disponibile
 - TCP non supporta il multicast
- TCP può essere usato per trasferire “file” multimediali (in email o in pagine web)

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