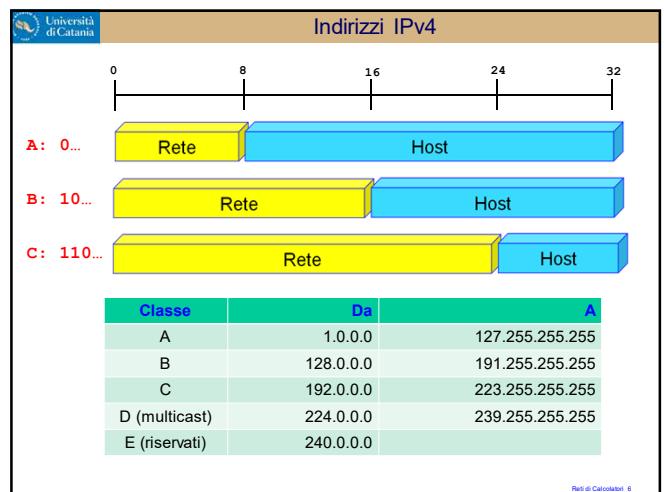
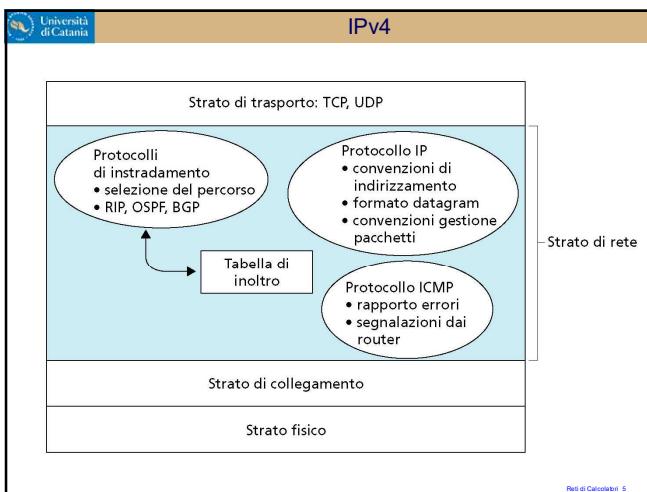


Circuito virtuale vs Datagram

	Datagram	Circuito Virtuale
Creazione circuito	No	Si
Informazioni di Stato	Indirizzi nei singoli pacchetti	Indirizzo di circuito
Instradamento	Nessuna informazione	Ogni circuito virtuale deve essere identificato
Effetti di guasti nei router	Nessuno, a parte i pacchetti persi	Fault in tutti i VC passanti per il router guasto
Controllo della congestione	Complesso	Semplice

Reti di Calcolatori: 4



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Le maschere di sottorete

Le maschere di sottorete

Rete Sottorete Host

Rete Sottorete 000000

10010111.01100001.11111100.01000010 151.097.252.066
11111111.11111111.11111110.0.00000000 255.255.254.000

AND

10010111.01100001.11111100.0.00000000 151.097.252.000

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Assegnamento Indirizzi IP

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di Catania

Assegnamento Indirizzi IP

Oggi esistono cinque RIR:

- **APNIC** (Asia Pacific Network Information Center): www.apnic.net.
- **ARIN** (American Registry for Internet Numbers): www.arin.net.
- **LACNIC** (Latin American and Caribbean Internet Addresses Registry): www.lacnic.net.
- **RIPE NCC** (Réseaux IP Européens Network Coordination Centre): www.ripe.net.
- **AFRINIC** (African Regional Internet Registry): www.afrinic.org.

Red di Catania | 11

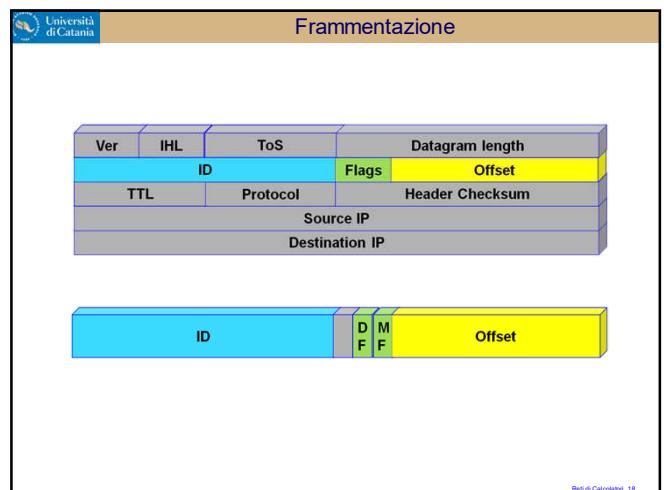
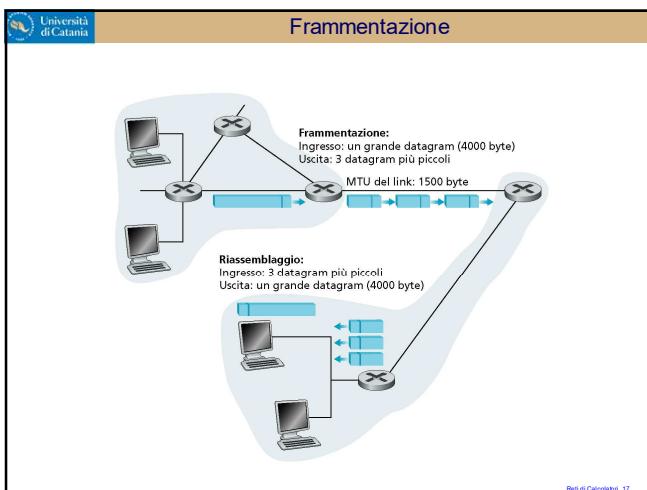
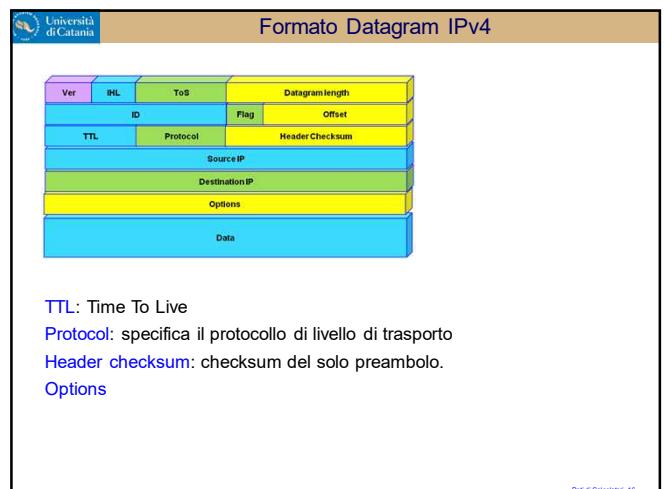
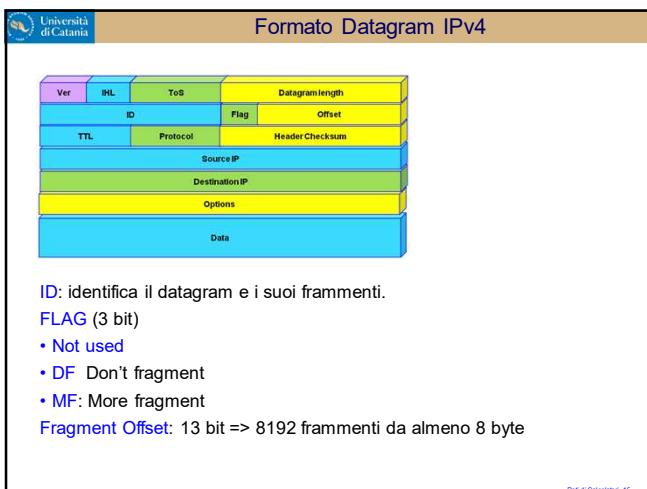
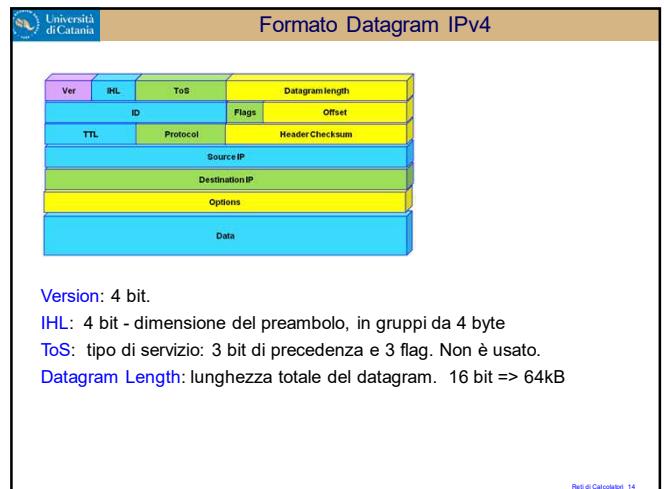
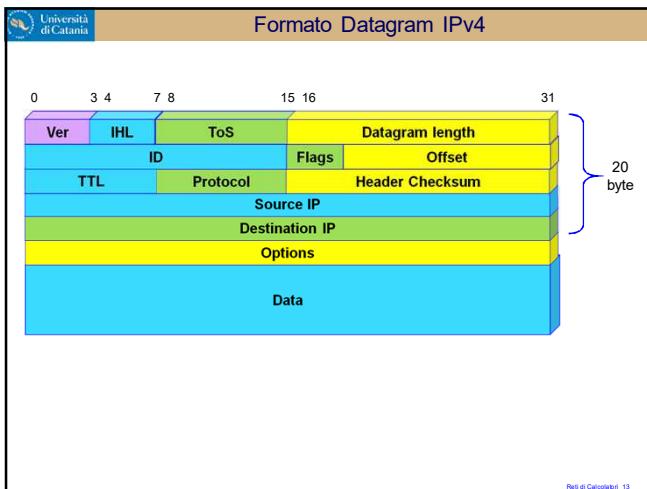
The diagram illustrates the IP address allocation process in Italy. It shows the GARR Network's peering points across various Italian cities (Rome, Milan, Naples, etc.) and its connection to international networks like AS4839 (AS4839) and AS4838 (AS4838). The legend indicates:

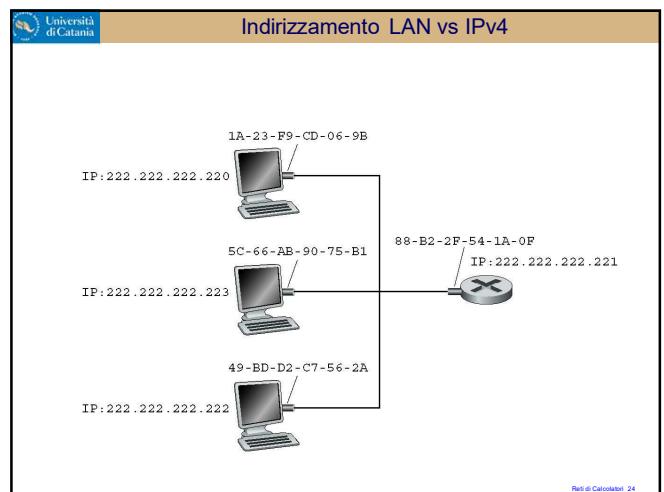
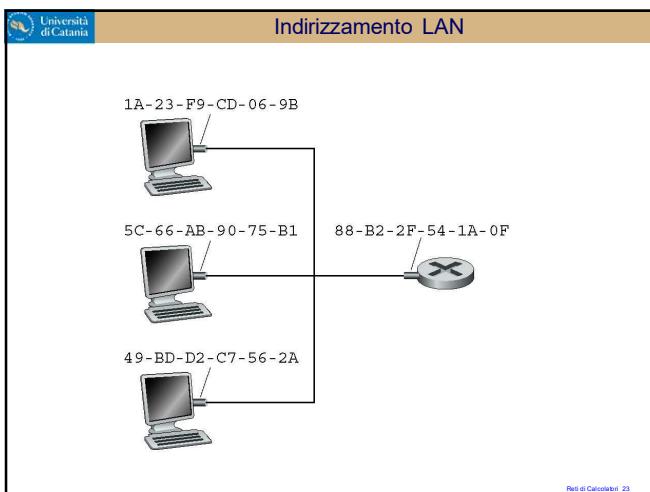
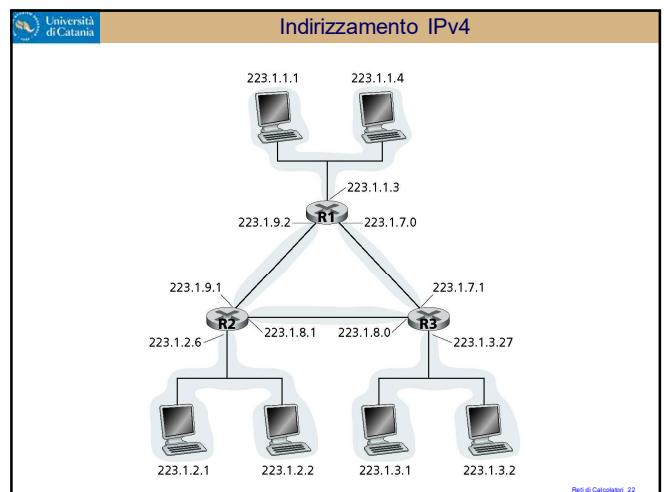
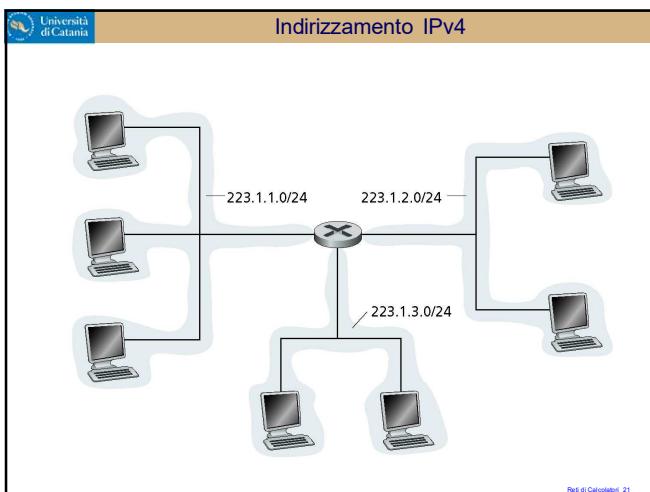
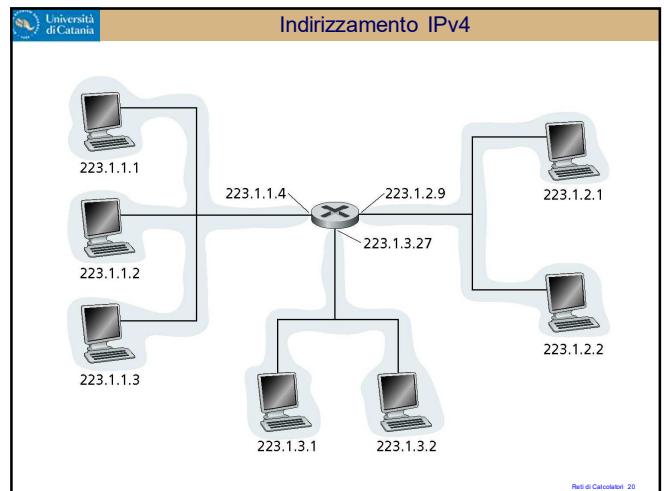
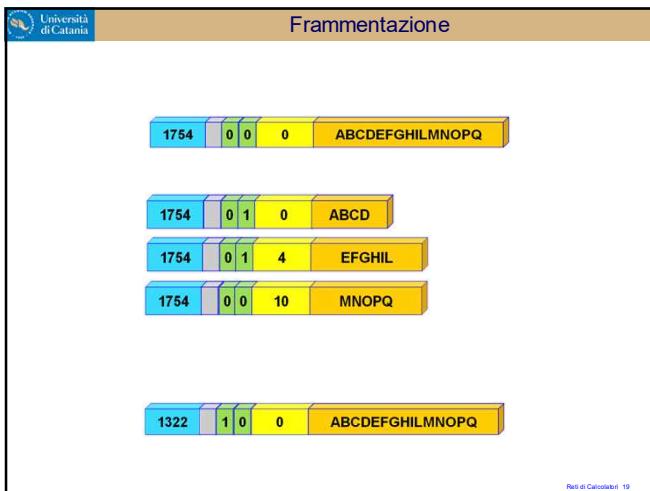
- GARR Network PvP
- OPTICAL FIBRE
- PEERING
- INTERNET PEERING
- Cross borders fibre
- INTERNET links

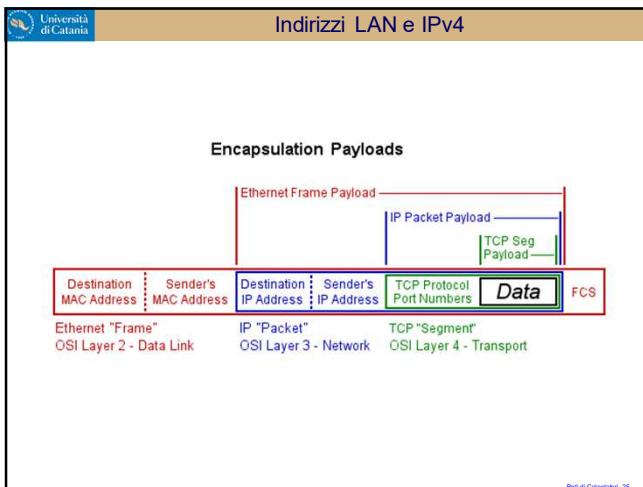
A callout box provides specific details for the link between RKL-CS and RKL-CT1:

Link Name	User	BW	Target options
RKL-CS - RKL-CT1		backbone: 40.00 Gbps	Peering: Catania-CatModello RKL-CS-garrnet (M0960) RKL-CT1-garrnet (M0960)
		90.147.82.246	90.147.82.245

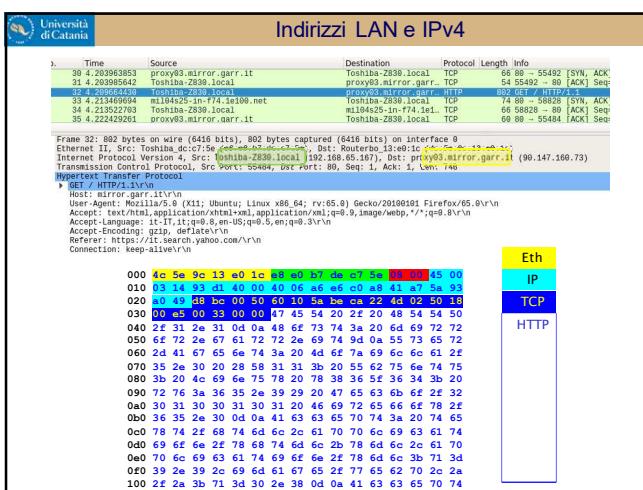
Below the map is a graph showing traffic flow between RKL-CS and RKL-CT1 (15840) over time, with data for both Ingress and Egress traffic.







Indirizzi LAN e IPv4								
b.	Time	Source	Destination	Protocol	Length	Info		
39	10:24:39.963853	proxy9.mirror.garr.it	Toshiba-2830.local	TCP	66	89 - 55492	[SYN, ACK]	
31	4.20.39.963852	Toshiba-2830.local	proxy9.mirror.garr.it	TCP	54	55492 - 88	[ACK]	Seq# 1
32	10:24:40.000000	Toshiba-2830.local	proxy9.mirror.garr.it	TCP	66	55492 - 88	[ACK]	Seq# 2
33	4.21.34.06.0904	m104425-21-in.7fe1e109.net	Toshiba-2830.local	TCP	74	89 - 58828	[SYN, ACK]	
34	4.21.34.06.2783	Toshiba-2830.local	m104425-21-in.7fe1e109.net	TCP	66	58828 - 88	[ACK]	Seq# 1
35	4.22.34.24.0002	proxy9.mirror.garr.it	Toshiba-2830.local	TCP	66	89 - 55484	[ACK]	Seq# 2
<hr/>								
Frame 32: 802 bytes on wire (6416 bits), 890 bytes captured (6416 bits) on interface eth0 Ethernet II, Src: Unknown (00:0c:29:dc:07:67), Dst: Unknown (00:0c:29:dc:07:6c) [ethernet-raw] Internet Protocol Version 4, Src: Toshiba-2830.local (192.238.29.102), Dst: proxy9.mirror.garr.it (98.147.160.73) Transmission Control Protocol, Src Port: 55484, Dst Port: 80, Seq: 1, Ack: 1, Len: 748 HyperText Transfer Protocol GET / HTTP/1.1\r\nHost: mirror.garr.it\r\nUser-Agent: Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:65.0) Gecko/20100101 Firefox/65.0\r\nAccept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/*;q=0.8\r\nAccept-Language: it-IT, it;q=0.9, en-US;q=0.1, en;q=0.1\r\nAccept-Encoding: gzip, deflate\r\nReferer: https://it.search.yahoo.com/\r\nConnection: keep-alive\r\n\r\n								
▶	Gecko/20100101 65.0 (Ubuntu; X11; Linux x86_64; rv:65.0) Gecko/20100101 Firefox/65.0							
▶	HTTP/1.1 200 OK							
▶	Date: Sun, 10 Nov 2018 08:45:07 GMT							
▶	If-Modified-Since: Sat, 09 Nov 2018 08:45:07 GMT							
▶	Upgrade-Insecure-Requests: 1							
▶	If-Modified-Since: Sat, 10 Nov 2018 08:45:07 GMT							
▶	If-Modified-Since: Sat, 09 Nov 2018 08:45:07 GMT							
806	4c:5c:13:9d:c1:68	b7 dc c7 5e 00 45 00	L:A	0	@ #	A-Z	
807	63 14 93 01 49 99	05 06 a9 41 47 54 93	9Z	0	Z	D	
808	00 00 00 00 00 00	00 00 00 00 00 00	00	0	-	-	
809	05 e9 89 89 89 89	45 54 29 27 20 48 54 58	0	- 3 GE T / HTTP	0	-	-	
848	27 31 20 31 93 00	78 49 07 26 69 72 72	1/-1	Ho St: mirr	0	-	-	
849	00 00 00 00 00 00	00 00 00 00 00 00	00	0	-	-	
860	00 00 00 00 00 00	00 00 00 00 00 00	00	0	-	-	
861	00 41 67 65 76 74	30 20 4d 67 7a 69 6c 6c 61 2f	0	- Agent: Mozilla/	0	-	-	
876	77 35 29 76 78 58	31 31 26 20 55 75 76 74 57	5 .. 6 (X11)Ubuntu	0	-	-	
877	38 31 88 38 31 26	46 69 72 05 66 78 76 78 2f	2fGecko/20100101 64.0	0	-	-	
898	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
899	38 31 88 38 31 26	46 69 72 05 66 78 76 78 2f	2fGecko/20100101 64.0	0	-	-	
900	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
901	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
902	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
903	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
904	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
905	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
906	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
907	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
908	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
909	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
910	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
911	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
912	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
913	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
914	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
915	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
916	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
917	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
918	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
919	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
920	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
921	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
922	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
923	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
924	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
925	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
926	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
927	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
928	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
929	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
930	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
931	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
932	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
933	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
934	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
935	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
936	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
937	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
938	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
939	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
940	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
941	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
942	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
943	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
944	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
945	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
946	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
947	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
948	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
949	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
950	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
951	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
952	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
953	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
954	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
955	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
956	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
957	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
958	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
959	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
960	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
961	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
962	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
963	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
964	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
965	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
966	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
967	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
968	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
969	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
970	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
971	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
972	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
973	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
974	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
975	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
976	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
977	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
978	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
979	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
980	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
981	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
982	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
983	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
984	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
985	77 36 35 39 39 29	20 47 65 63 68 6f 2f 32	rv:85.83	Gecko/2	0	-	-	
986	77 36 35 39 39 29	20 47 65 63 68 6f 2f						



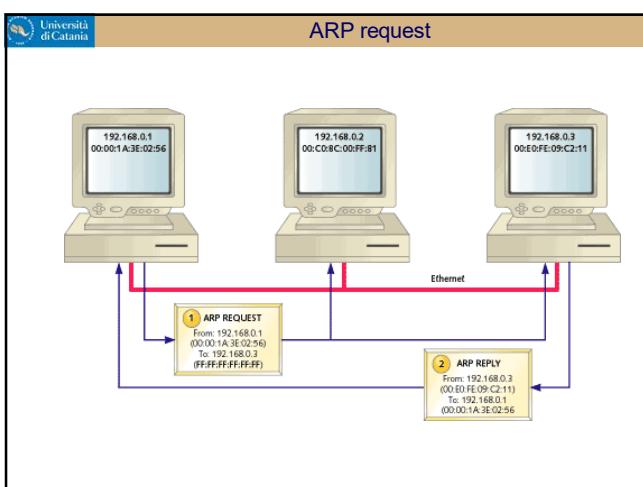
Indirizzi LAN e IPv4									
	Time	Source	Destination	Protocol	Length	Info			
34	9:40:2009063853	proxy03.mirror.garr.it	Toshiba-2838.local	TCP	68	98 - 55492 [SYN, ACK]			
31	4:203985642	Toshiba-2838.local			54	55492 - 80 [ACK]	Seq:		
32	4:200664430	Toshiba-2838.local	proxy03.mirror.garr.it	HTTP	807	GET /HTTP/1.1			
33	4:212527863	Toshiba-2838.local	192.168.65.167	TCP	68	98 - 55492 [SYN, ACK]			
34	4:212527863	Toshiba-2838.local	192.168.65.167	TCP	68	98 - 55492 [ACK]			
35	4:222429261	proxy03.mirror.garr.it	Toshiba-2838.local	TCP	68	98 - 55484 [ACK]			

Frame 32: 892 bytes on wire (6416 bits), 802 bytes captured (6416 bits) on interface 8
 Ethernet II, Src: Toshiba_dcc7:5e (48:08:07:dc:7:5e), Dst: Router1_3:e0:1c (4c:5e:0c:13:e0:1c)
 Internet Protocol Version 4, Src: Toshiba-2838.local (192.168.65.167), Dst: proxy03.mirror.garr.it (90.147.160.73)
 Transmission Control Protocol, Src Port: 55484, Dst Port: 80, Seq: 1, Ack: 1, Len: 748

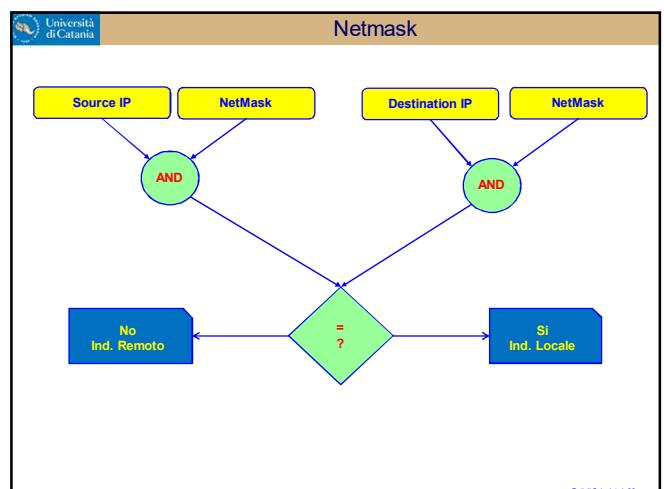
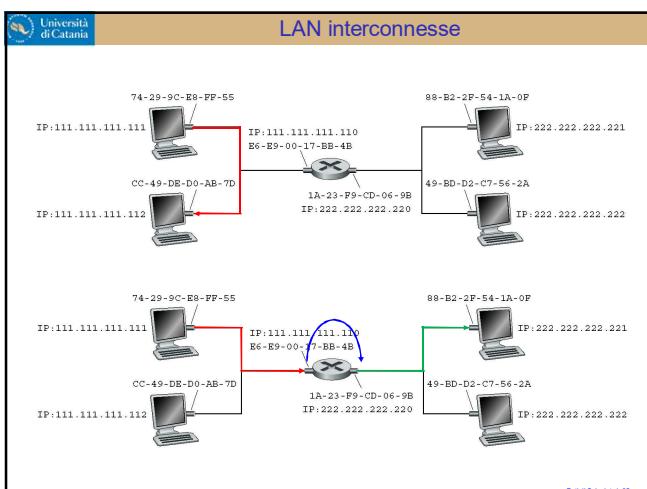
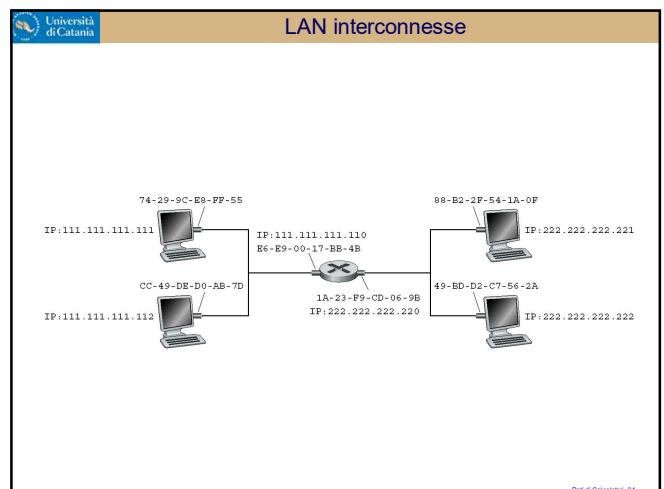
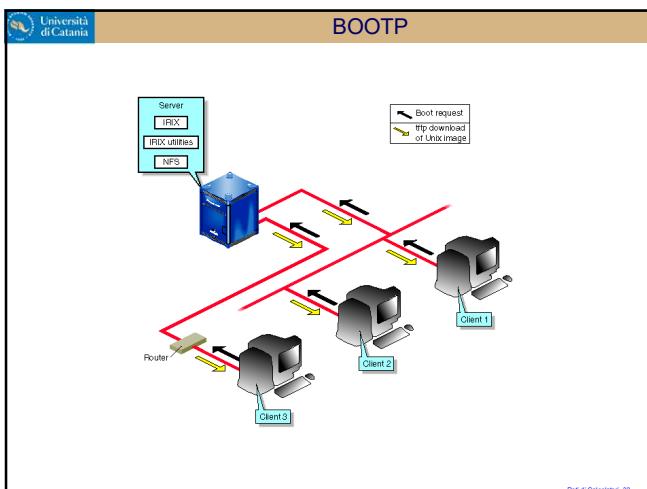
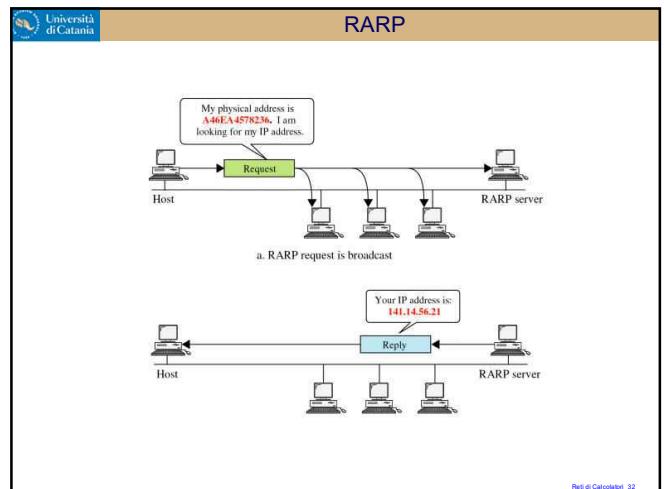
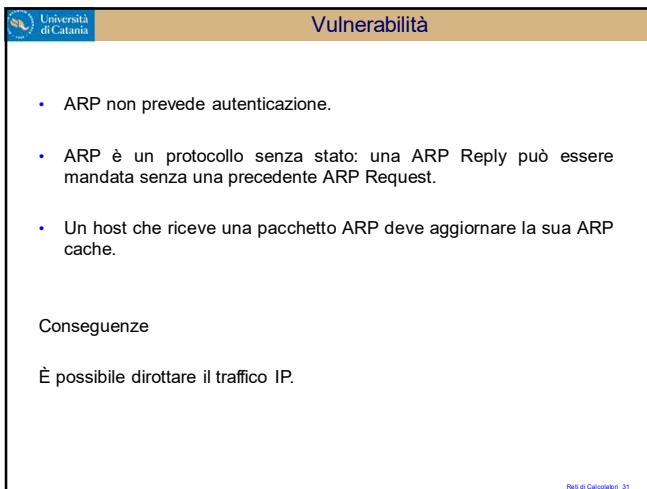
Transmission Control Protocol, Src Port: 55484, Dst Port: 80, Seq: 1, Ack: 1, Len: 748

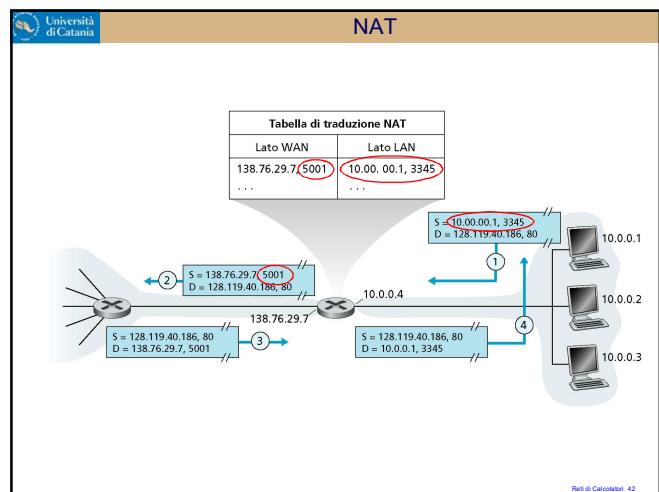
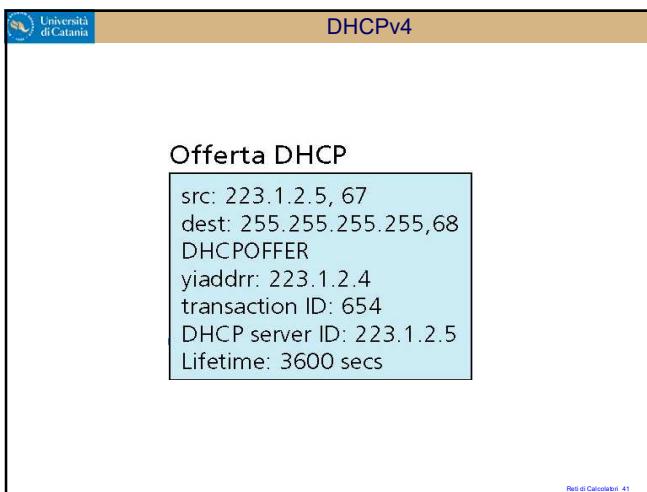
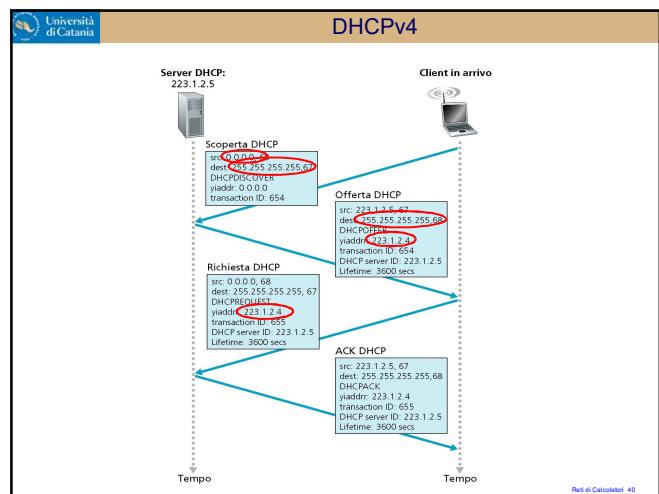
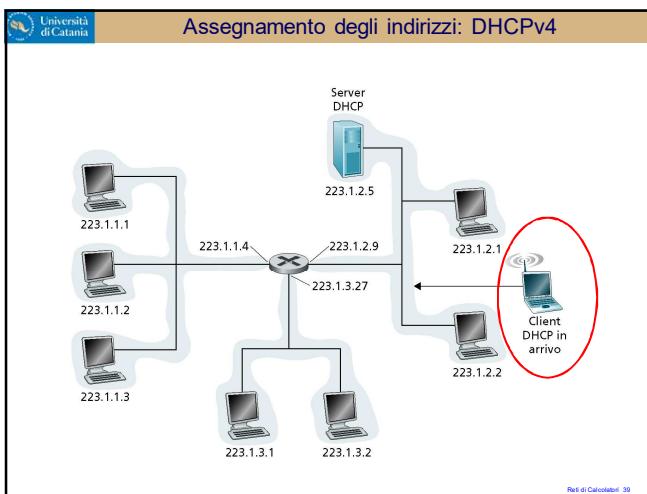
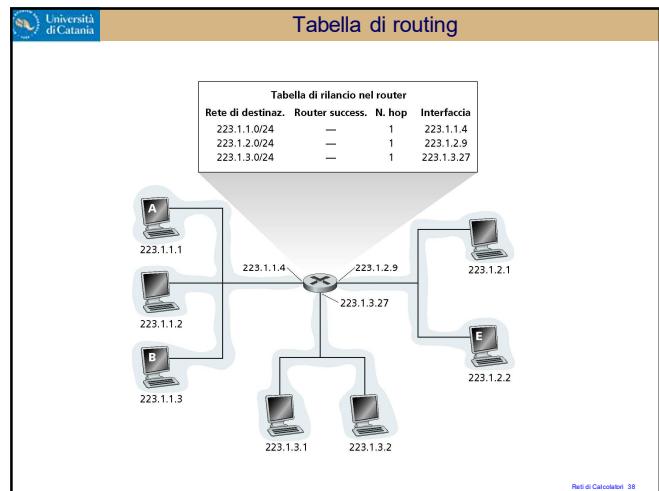
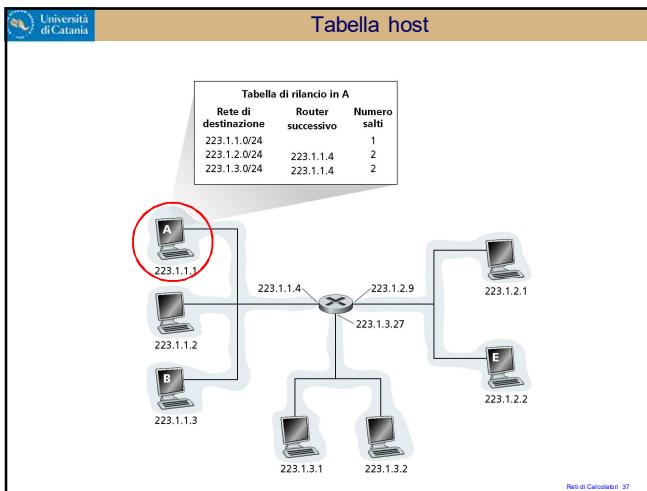
Ver	IHL	ToS	Datalen	Length
ttl	id	Flag	Offset	
TTL	Protocol	Header Checksum		
54	93	0A	49	Source IP
db	bc	00	50	Destination IP
60	10	1a	be	Options
ca	22	4d	02	
50	19	00	e4	
00	33	00	00	Data

Ver 04 IHL 05 ToS 03 DL 0314 (788 = 802-6-6-2)
 ID 93D1 Flag + offset 010 0000000000000000
 TTL 40 (64) Protocol 06 (TCP) HC A6E6
 Source IP C0 (192) A8 (168) 41 (065) A7 (167)
 Dest IP 5A (090) 93 (147) A0 (160) 49 (073)



ARP table		
Indirizzo IP	Indirizzo LAN	TTL
222.222.222.221	88-B2-2F-54-1A-0F	13:45:00
222.222.222.223	5C-66-AB-90-75-B1	13:52:00





IPv6

"If Y2K was technology's ticking time bomb, then IPv6 is a slow, deadly gas leak."

Reti di Calcolatori 43

IPv6

Limiti di IPv4

- Esaurimento dello spazio degli indirizzi
- Scalabilità del routing
- Nuovi servizi

Reti di Calcolatori 44

Famous Last Words

"I think there is a world market for maybe five computers"
– Thomas Watson (IBM), 1943

"640K ought to be enough for anybody"
– Bill Gates (MS), 1981

"32 bits should be enough address space for the Internet"
– Vint Cerf (ARPA), 1977

Reti di Calcolatori 45

IPv4 Address Allocation

IPv4 Addresses Available in October 17, 2010 according to the RIPE

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

Hobbes' Internet Timeline Copyright ©2010 Robert H Zekon
<http://www.zekon.org/reb/internet/timeline/>

Reti di Calcolatori 46

IPv4 Address Allocation

RIRs IPv4 Whois Map October 2007

This map shows the characteristics of IPv4 whois data from the October 2007 RIPE Whois database. Each pixel in the full-size image represents a /24 network block contained in the database. The darker the color, the more networks which are assigned to that RIR. Thus, the most heavily shaded areas correspond to the RIRs with the largest number of networks appearing in the whois data.

Each network block is shaded with varying levels of gray to indicate the number of hosts assigned to that network. The darker the shade, the more hosts which are assigned to that network. Thus, the most heavily shaded areas correspond to the RIRs with the largest number of hosts assigned to their networks.

Network blocks which are listed in multiple RIRs are shaded with a light gray. This indicates that they are registered with multiple RIRs, either because they are large networks or because they are located in multiple countries.

Reti di Calcolatori 47

IPv4 routing

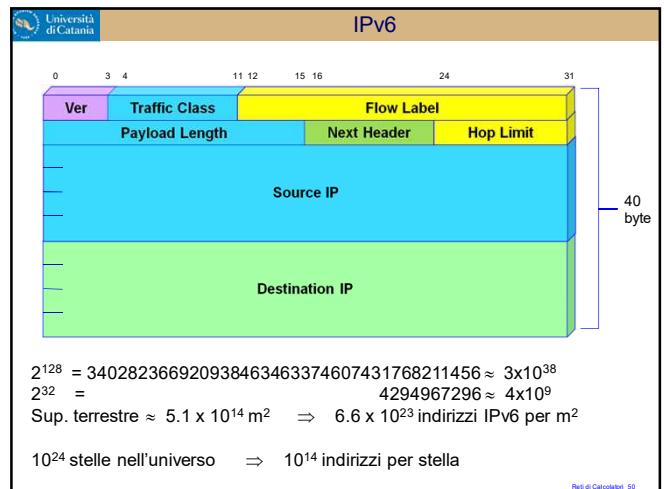
Reti di Calcolatori 48

IPv6

Nuovi Servizi richiesti :

- Sicurezza
- Autoconfigurazione (Plug & Play)
- Gestione della Qualità del Servizio (QoS)
- Indirizzamento Multicast
- Indirizzamento host mobili

Reti di Calcolatori 49



Confronto delle intestazioni

IPv6

0 4 8 16 19 31	0 4 12 16 24 31
Vers. HLEN Traffic Class	Version
Identification	Traffic Class
Flags Fragment Offset	Flags
Time To Live Protocol Header Checksum	Total Length
Source IP Address	Source IP Address
Destination IP Address	Destination IP Address
Options PAD	Options PAD

Rimossi

- ID, Flags, Offset
- ToS, HLEN
- Header Checksum

Cambiati

- Total length \Rightarrow payload
- Protocol \Rightarrow next header
- TTL \Rightarrow hop limit

Aggiunti

- Traffic class
- Flow label

Espansi

- address: 32 \Rightarrow 128 bits

Reti di Calcolatori 51

Indirizzi IPv6

0000 0000	Riservati (includono IPv4)
0000 001	Indirizzi OSI NSAP (deprecated)
0000 010	Indirizzi Novell IPX
001	Indirizzi unicast globali
010	Indirizzi per service providers
100	Indirizzi geografici
1111 1110 10	Indirizzi unicast link-local
1111 1110 11	Indirizzi unicast site-link (deprecated)
1111 1111	Multicast

Reti di Calcolatori 52

Indirizzi IPv6

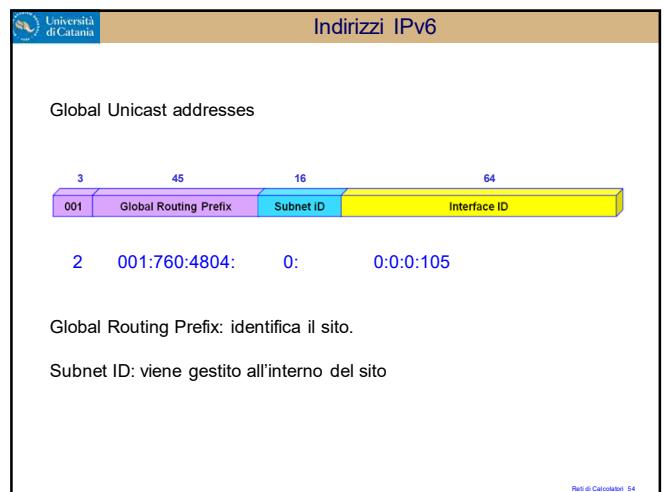
8000:0000:0000:0000:0123:4567:89AB:CDEF

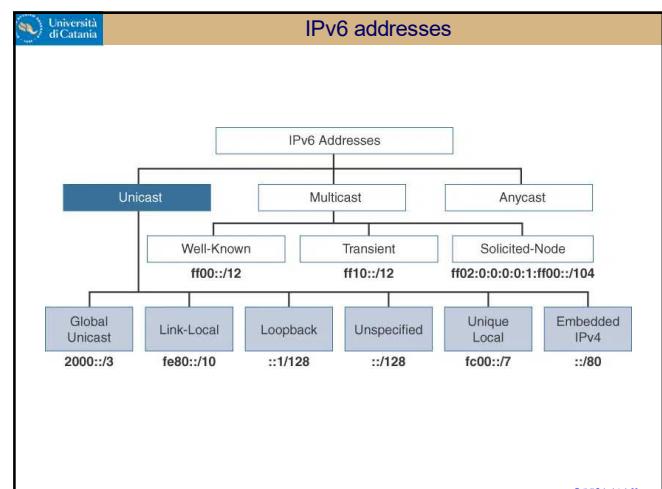
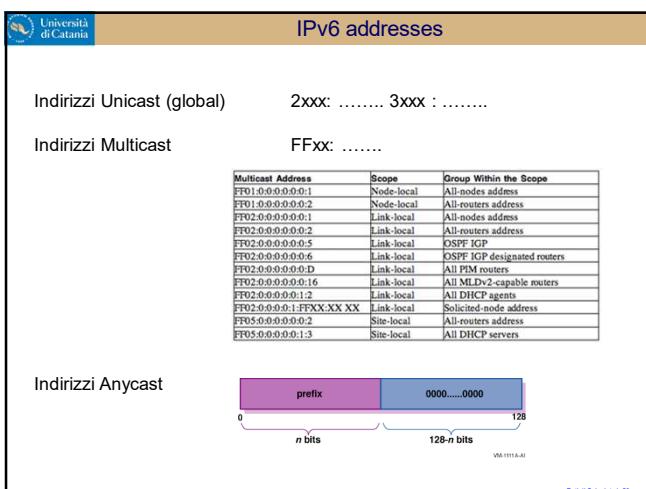
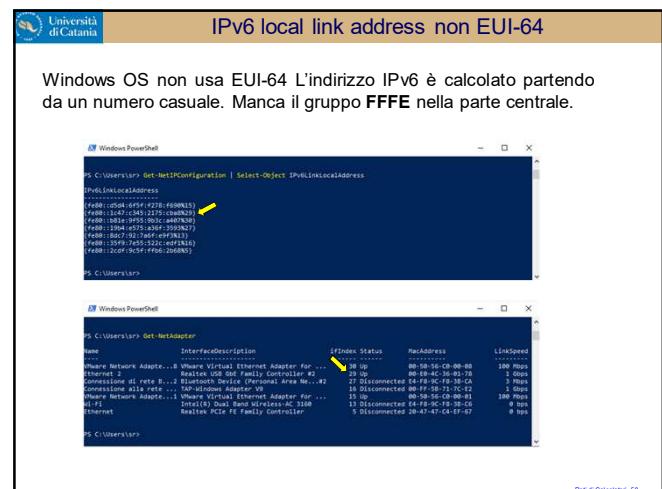
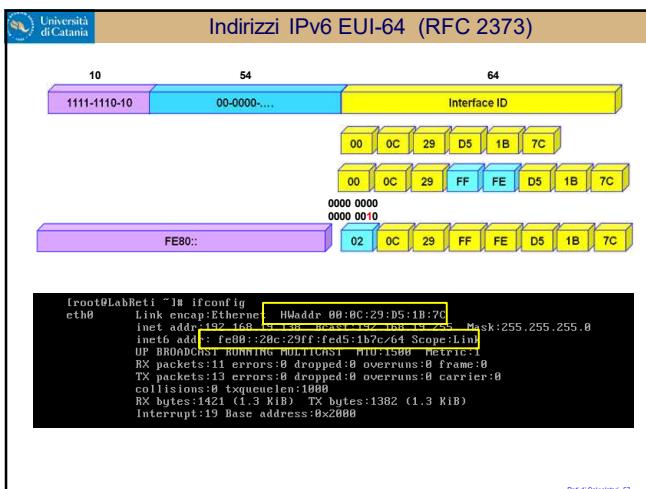
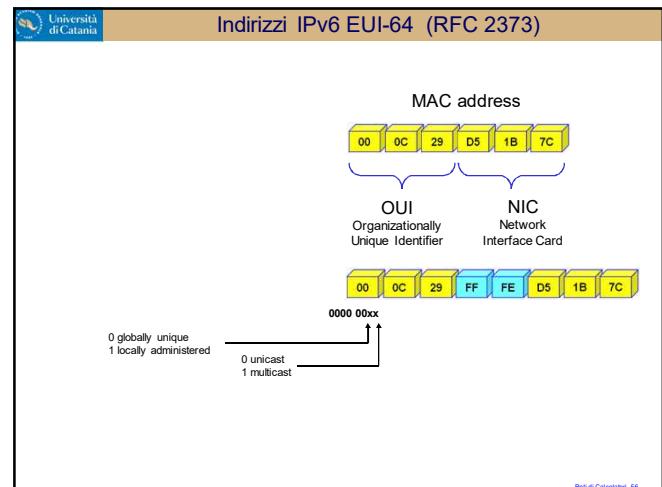
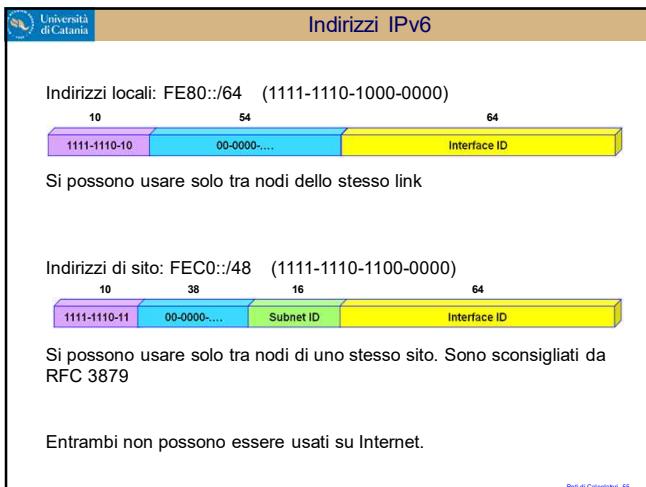
8000::123:4567:89AB:CDEF

2001:760:4804:0:0:0:105
2001:760:4804::48

::151.97.1.1 indirizzo IPv4 mappato su IPv6
::1 loopback
:: non specificato

Reti di Calcolatori 53





IPv6 over Ethernet

IPv6 Ethernet encapsulation (RFC 2464)

I pacchetti IPv6 sono incapsulati in frame Ethernet esattamente come per i pacchetti IPv4: cambia solo il campo Ethertype (86DD invece che 0800).

Reti di Calcolatori - 61

Neighbour discovery (NDP) (RFC 4861)

NDP fornisce i seguenti servizi:

- Router discovery
- Prefix discovery
- Parameter discovery
- Address Autoconfiguration
- Address resolution
- Next-hop determination
- Neighbor unreachability detection
- Duplicate address detection
- Redirect messages

Reti di Calcolatori - 62

Neighbour Discovery Protocol

- Address Resolution Protocol (ARP),
- Internet Control Message Protocol (ICMP) [router discovery](#),
- ICMP [Redirect message](#)

ARP non fa parte di ICMPv4. Aver incorporato il meccanismo di risoluzione degli indirizzi mac in ICMPv6, rende il tutto più indipendente dal tipo di mezzo fisico e consente l'utilizzo di meccanismi di sicurezza

Reti di Calcolatori - 63

Neighbour Discovery Protocol

NDP prevede 5 messaggi:

- Router Solicitation (ICMPv6 type 133)
- Router Advertisement (ICMPv6 type 134)
- Neighbor Solicitation (ICMPv6 type 135)
- Neighbor Advertisement (ICMPv6 type 136)
- Redirect (ICMPv6 type 137)

Reti di Calcolatori - 64

Classi di Traffico IPv6

000 -111 = time insensitive (could be discarded)
 1000 -1111 = priority (should not be discarded)

0 = uncharacterized

1 = filler (NetNews)

2 = unattended transfer (mail)

4 = bulk (ftp)

6 = interactive (telnet)

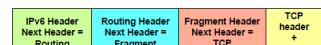
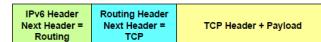
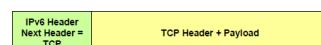
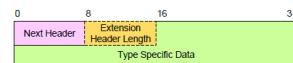
7 = Internet control

8 = video

15 = low quality audio

Reti di Calcolatori - 65

Header opzionali



Reti di Calcolatori - 66

Header opzionali

0	HBH	Hop-by-Hop option (IPv6) (Jumbogram)
1	ICMP	Internet Control Message (IPv4)
2	IGMP	Internet Group Management (IPv4)
3	GGP	Gateway-to-Gateway Protocol
4	IP	IP in IP (IPv4 encapsulation)
5	ST	Stream
6	TCP	Transmission Control
8	EGP	Exterior Gateway Protocol
9	IGP	Any private interior gateway
16	CHAOSS	Chaos
17	UDP	User Datagram
29	ISO-T4P	ISO Transport Protocol Class 4
36	XTP	XTP
43	RDP	Routing header (IPv6)
44	FH	Frammentation Header (IPv6)
45	IDRP	Inter-Domain Routing Protocol
46	RSVP	Reservation Protocol
50	ESP	Encapsulating Security Payload
51	AH	Authentication header (IPv6)
54	NHRP	NBMA Next Hop Resolution Protocol
58	ICMP	Internet Control Message (IPv6)
59	Null	No next header (IPv6)
60	DODH	Destination Options header (IPv6)
80	ISO-IP	ISO Internet Protocol (CLNP)
83	VINES	
88	IGRP	IGRP
89	OSPF	OSPF (Open Shortest Path First)
93	AX.25	AX.25 Frames

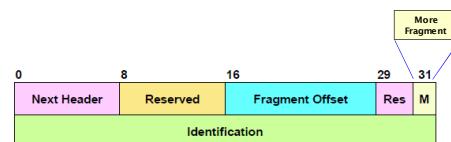
Reti di Calcolatori 67

Frammentazione

In IPv4 qualunque nodo può frammentare.

In IPv6 la frammentazione è scoraggiata. (RFC 1981 – MTU Path discovery for IPv6). Il minimo MTU è 1280 byte, con 1500 raccomandati.

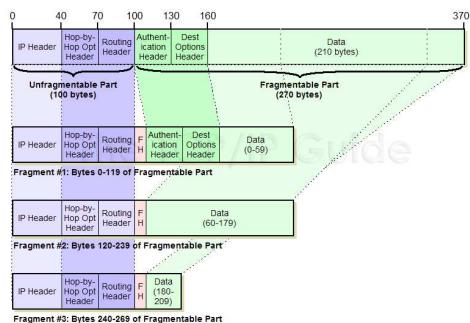
Solo il mittente può frammentare, tramite un Fragment Header.



Reti di Calcolatori 68

Frammentazione

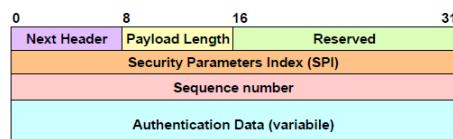
Il pacchetto IPv6 può essere frammentato solo dopo il FH. Tutto ciò che è prima non deve essere frammentato.



Reti di Calcolatori 69

Sicurezza

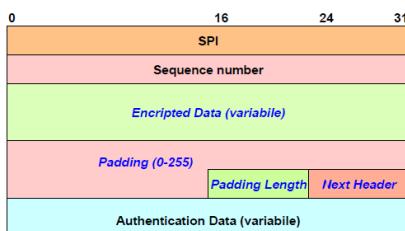
Authentication Header Garantisce l'autenticità e la correttezza del pacchetto.



Reti di Calcolatori 70

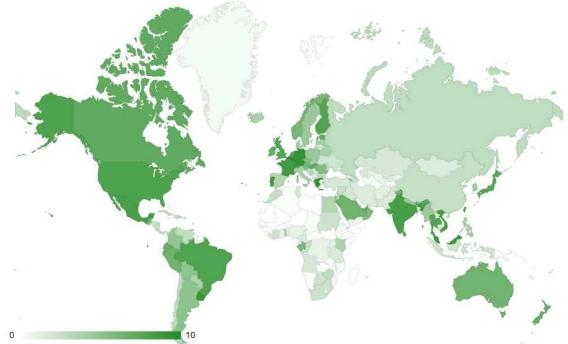
Sicurezza

Encrypted security payload Header. Fornisce la cifratura del payload.

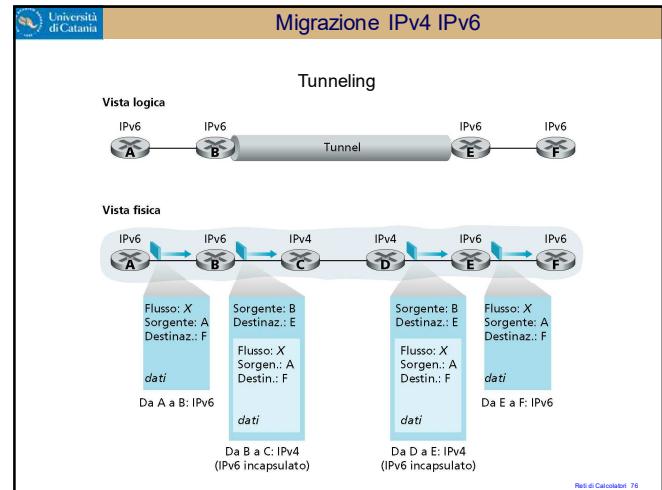
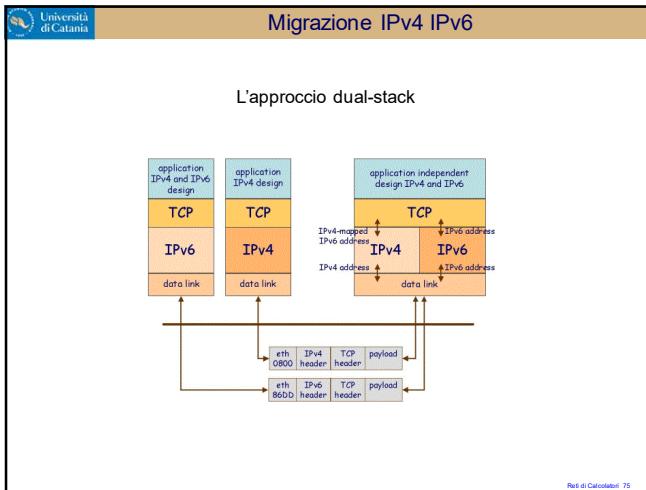
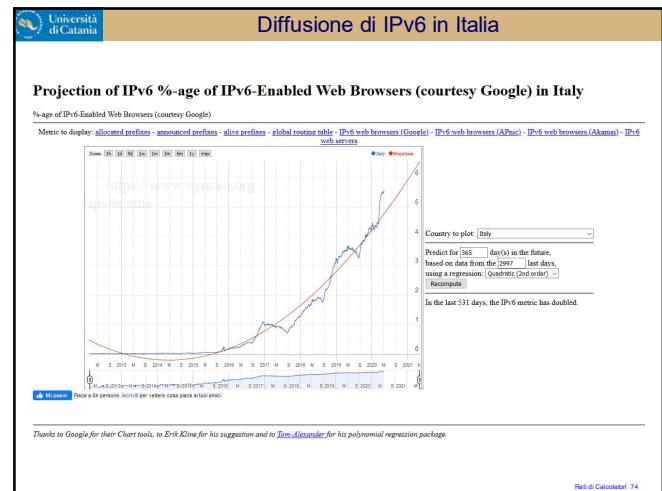
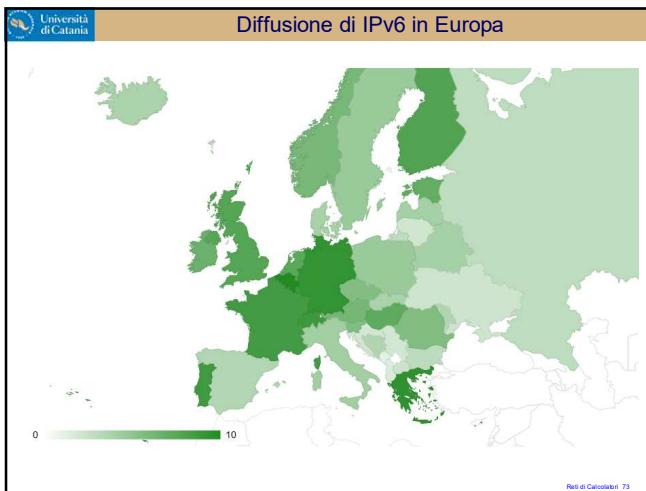


Reti di Calcolatori 71

Diffusione di IPv6



<https://6lab.cisco.com/stats/index.php>
Reti di Calcolatori 72



ICMPv4

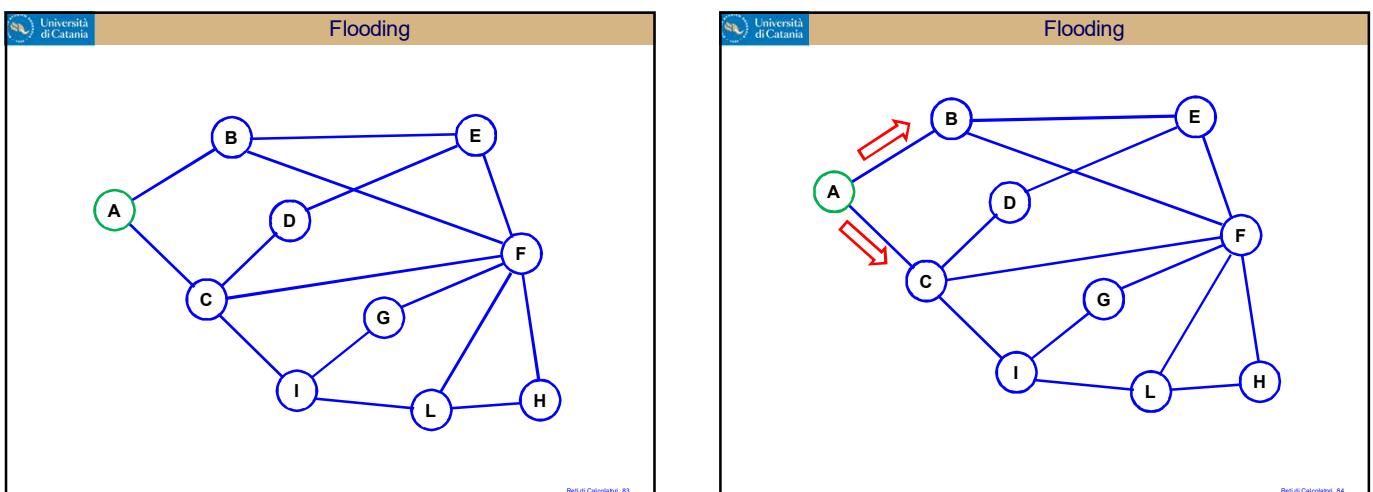
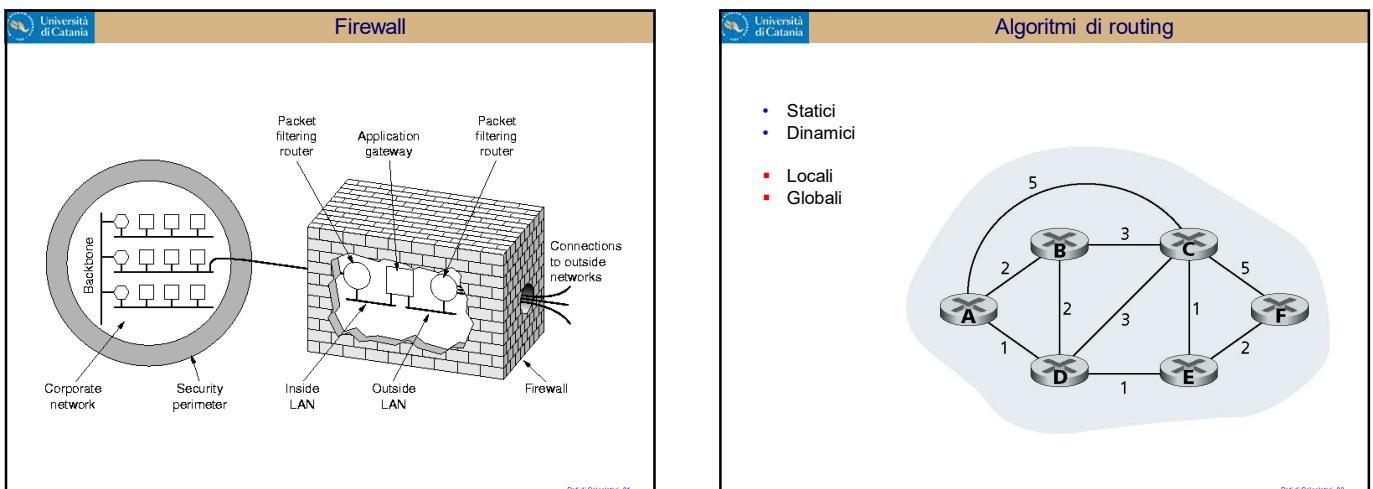
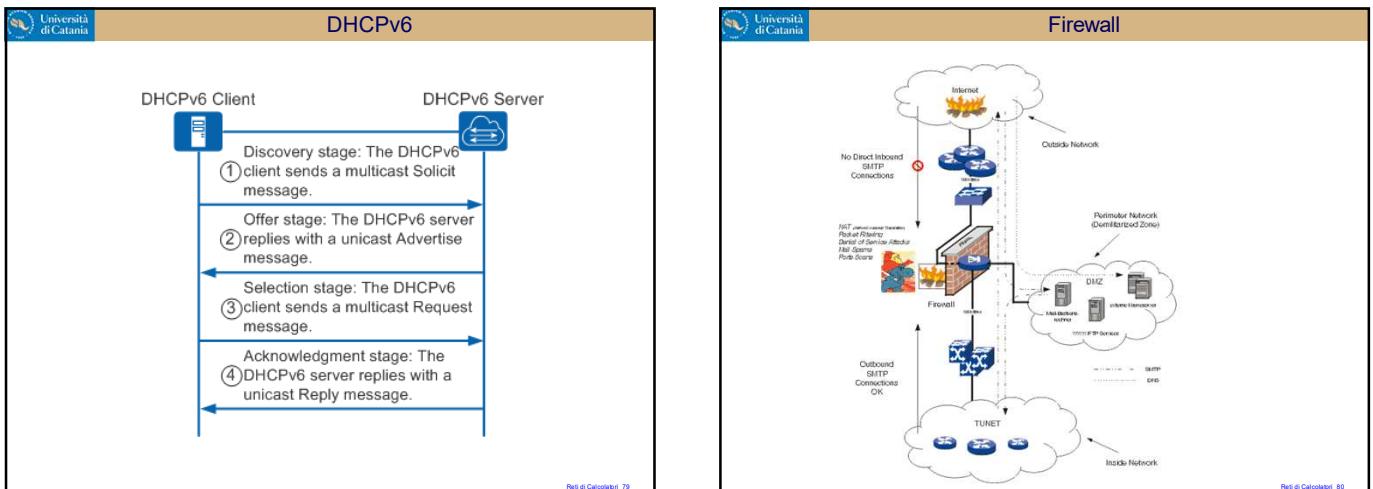
ICMP Tipo	Codice	Descrizione
0	0	risposta al messaggio di eco (ping) - <i>echo replay</i>
3	0	rete di destinazione irraggiungibile - <i>destination network unreachable</i>
3	1	host di destinazione irraggiungibile - <i>destination host unreachable</i>
3	2	protocollo di destinazione irraggiungibile - <i>destination protocol unreachable</i>
3	3	porta di destinazione irraggiungibile - <i>destination port unreachable</i>
3	6	rete di destinazione sconosciuta - <i>destination network unknown</i>
3	7	host di destinazione sconosciuto - <i>destination host unreachable</i>
4	0	strozzamento della sorgente (controllo della congestione) - <i>source quench</i>
8	0	richiesta di eco - <i>echo request</i>
9	0	annuncio dal router - <i>router advertisement</i>
10	0	scoperta del router - <i>router discovery</i>
11	0	TTL scaduto - <i>TTL expired</i>
12	0	cattiva intestazione IP - <i>IP header bad</i>

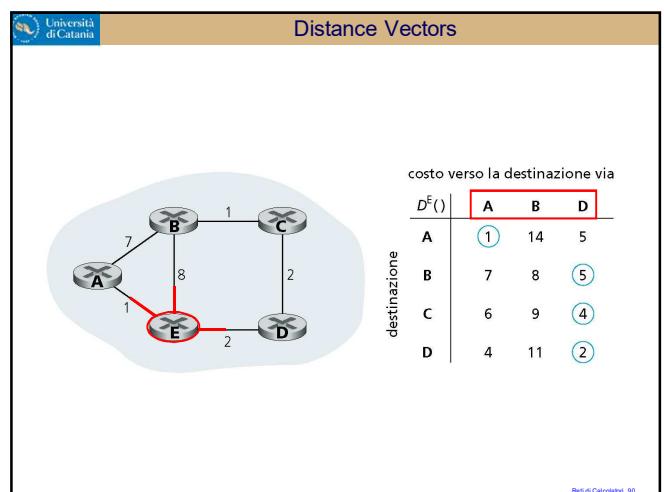
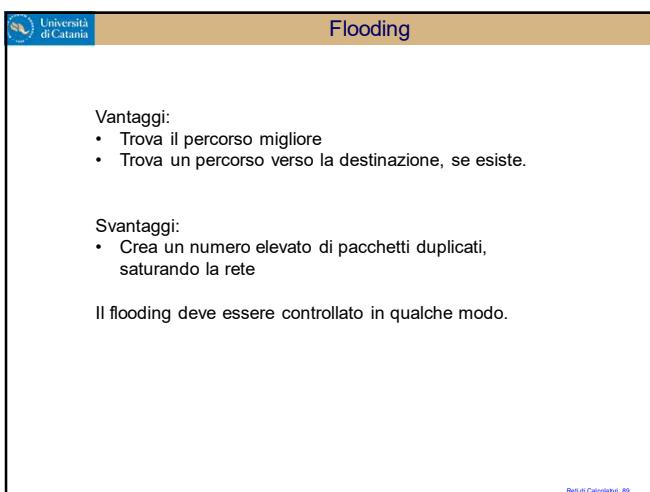
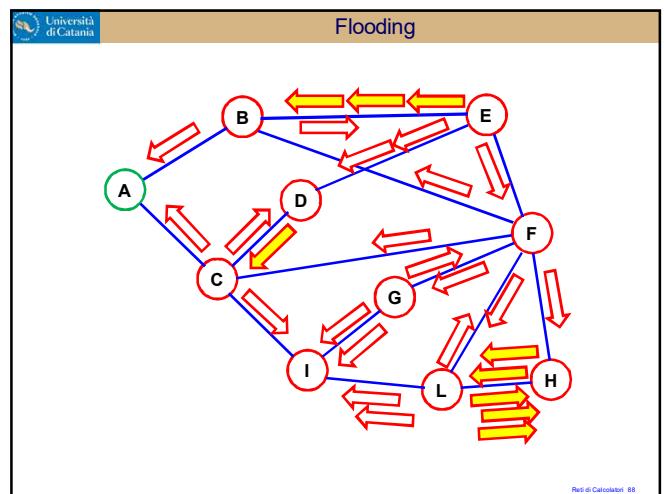
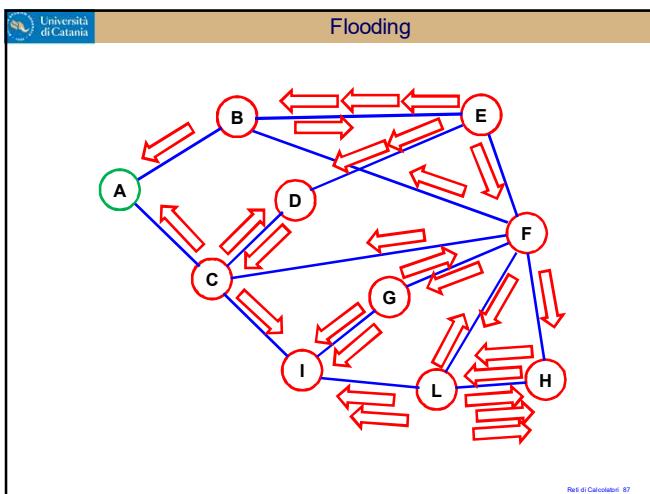
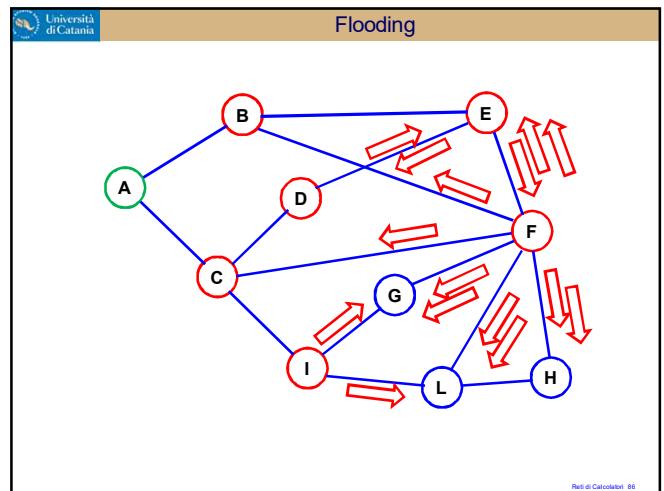
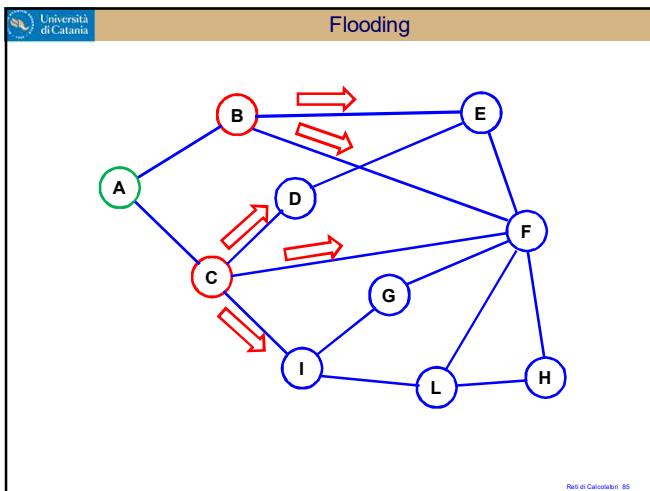
Reti di Calcolatori - 77

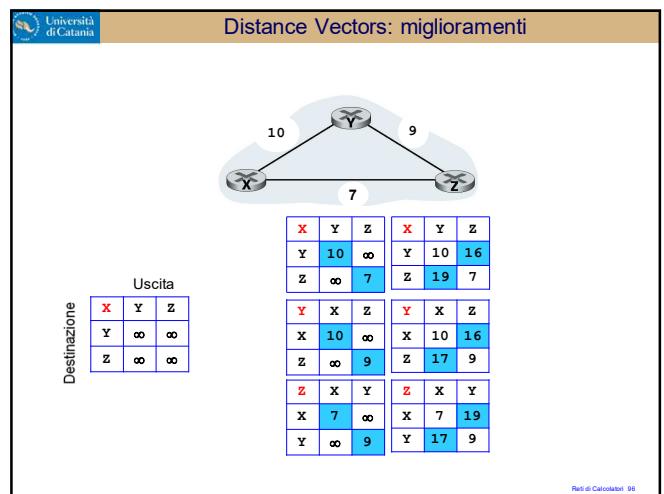
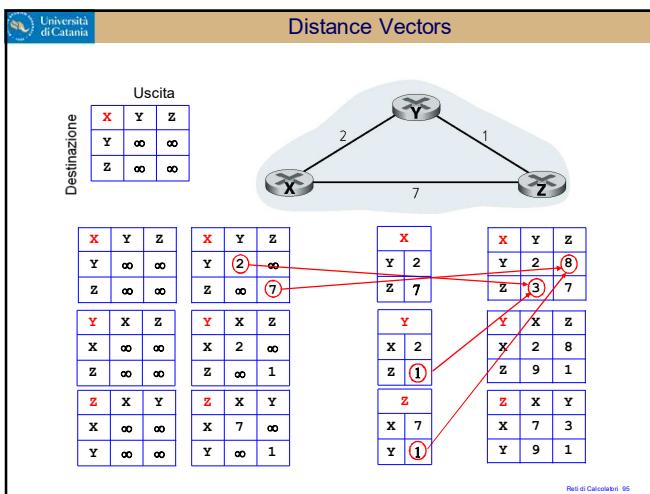
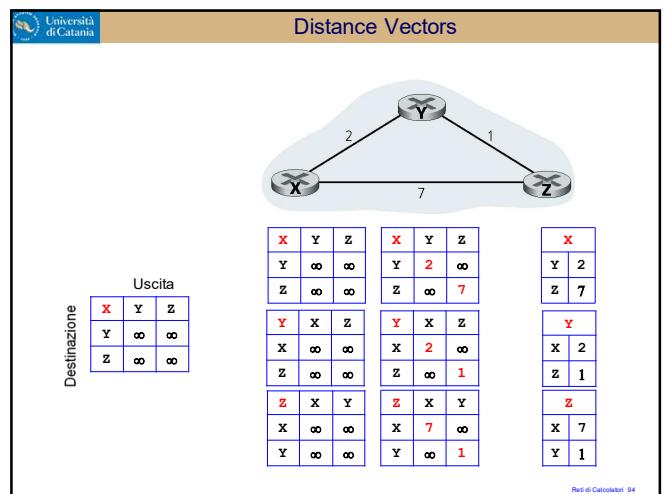
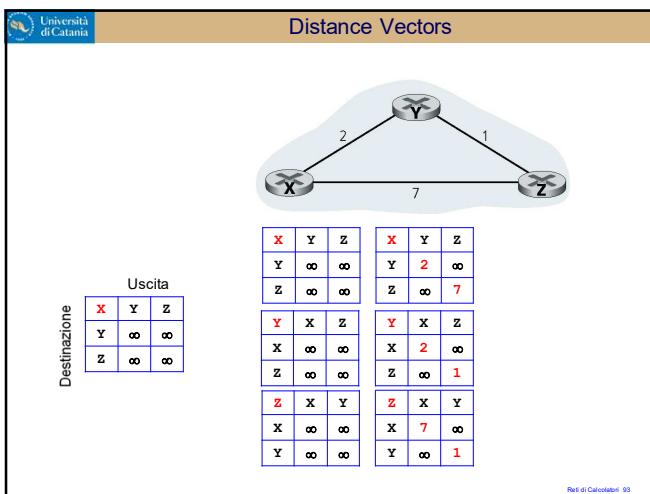
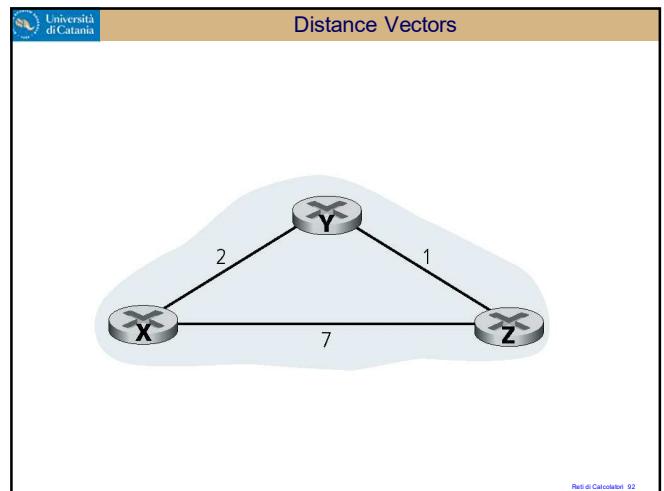
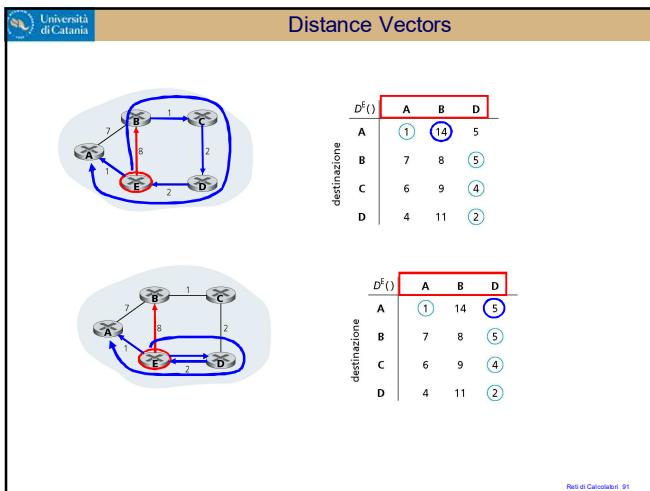
ICMPv6

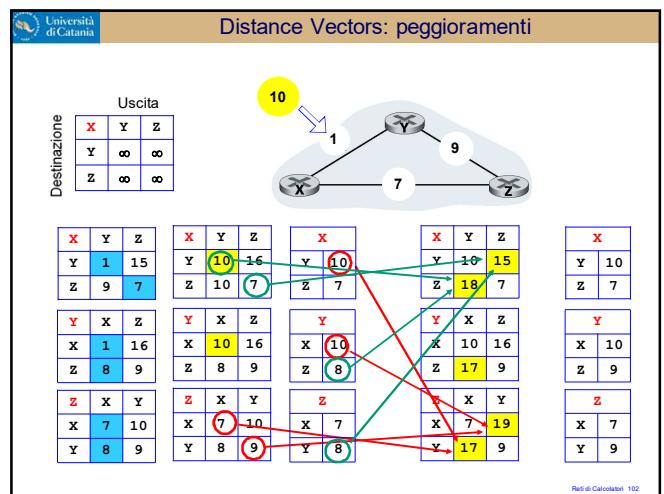
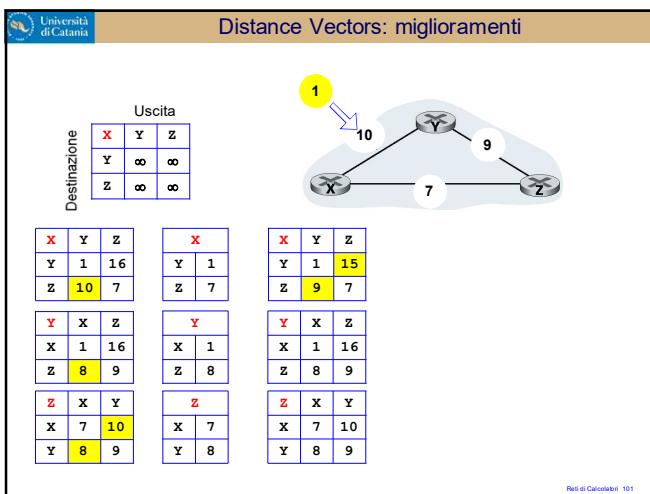
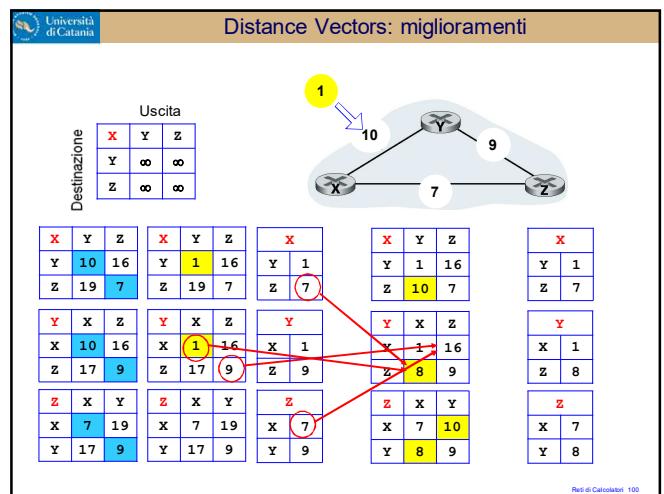
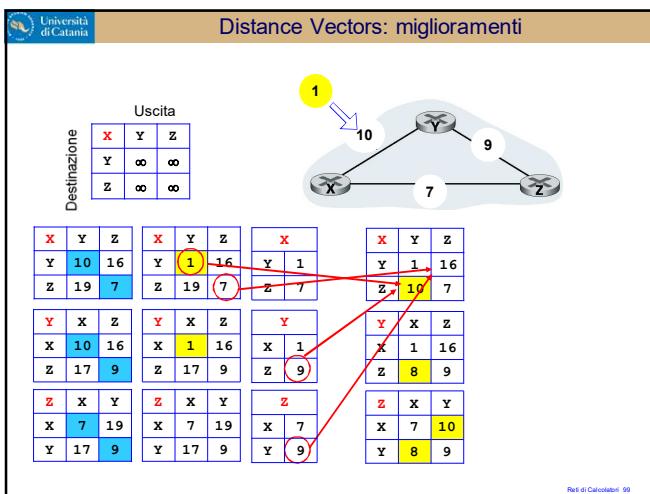
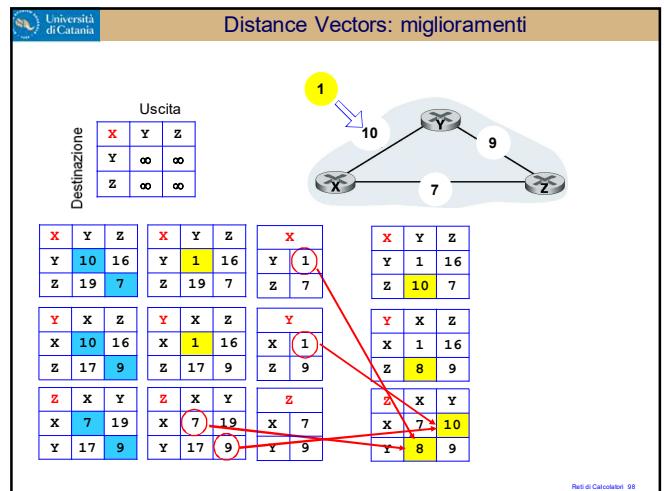
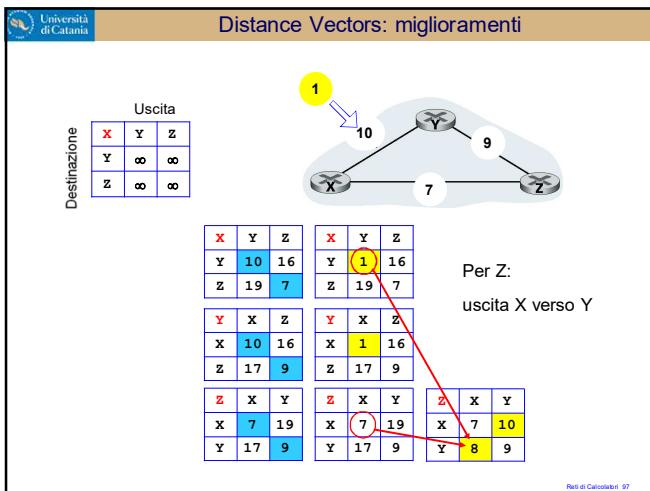
Type	Meaning
1	Destination Unreachable
2	Packet Too Big
3	Time Exceeded
4	Parameter Problem
128	Echo Request
129	Echo Reply
130	Group Membership Query
131	Group Membership Report
132	Group Membership Reduction
133	Router Solicitation
134	Router Advertisement
135	Neighbor Solicitation
136	Neighbor Advertisement
137	Redirect
138	Router Renumbering

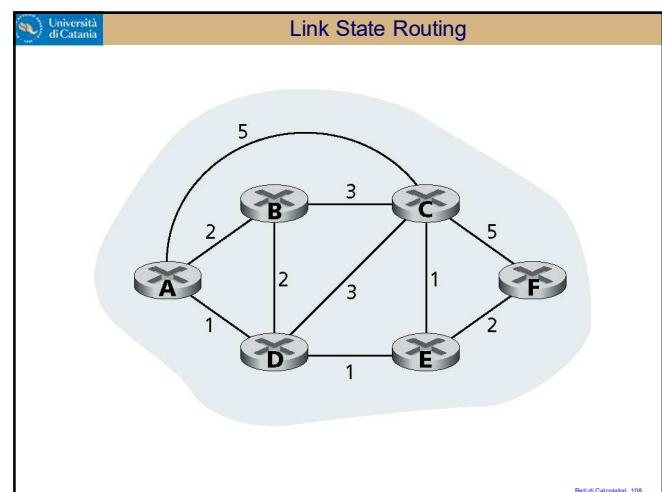
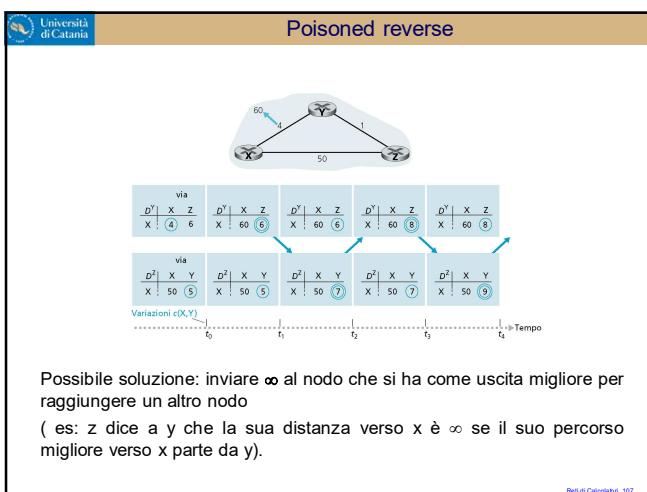
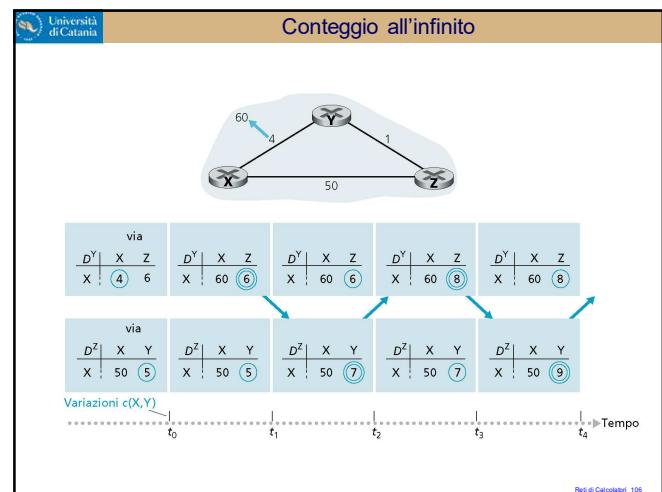
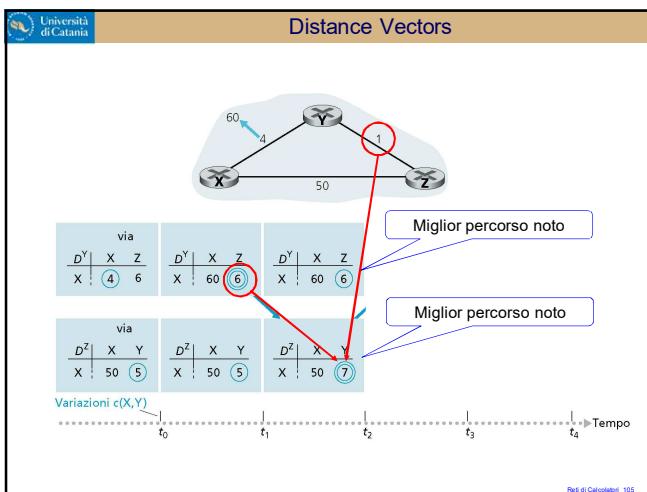
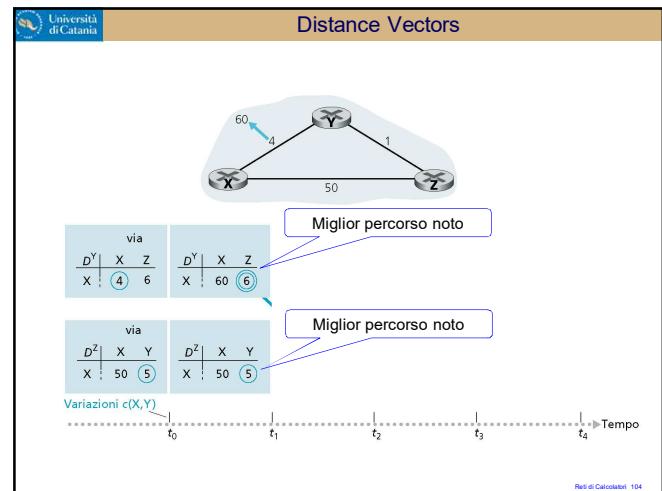
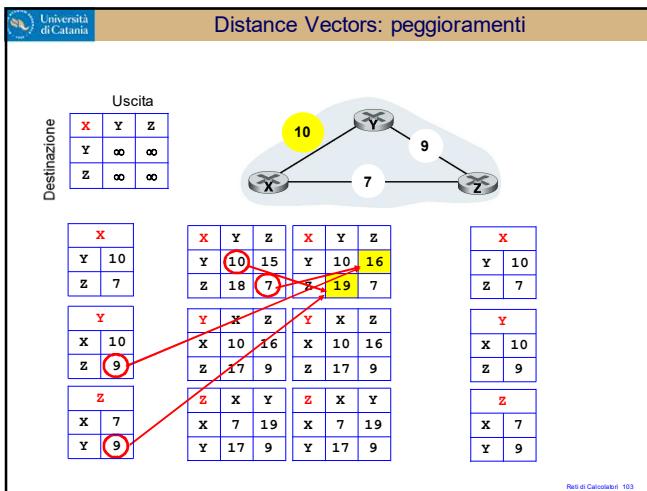
Reti di Calcolatori - 78



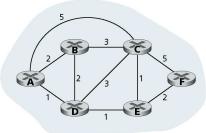








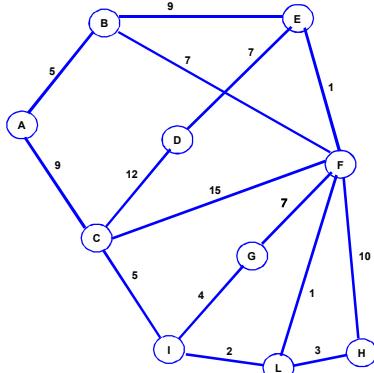
Link State Routing



La prima versione di Arpanet utilizzava il **Distance Vector Routing**
L'algoritmo venne sostituito dopo il 1979 con il **Link State Routing** in quanto il primo non teneva conto delle capacità dei canali ma solo dei tempi di ritardo di trasmissione.
Con questo algoritmo, ogni router indaga sui propri vicini e determina i **costi** di comunicazione. Spedisce quindi le informazioni in broadcast, in modo che ogni router possa calcolare i percorsi ottimali.
Il calcolo è basato sull'algoritmo di **Dijkstra**.

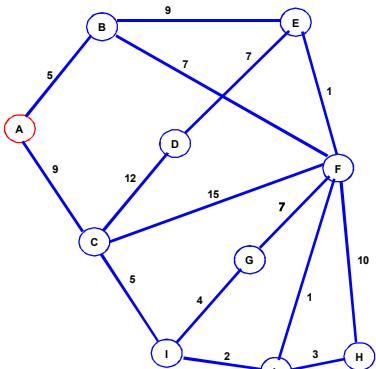
Reti di Calcolatori - 109

Dijkstra



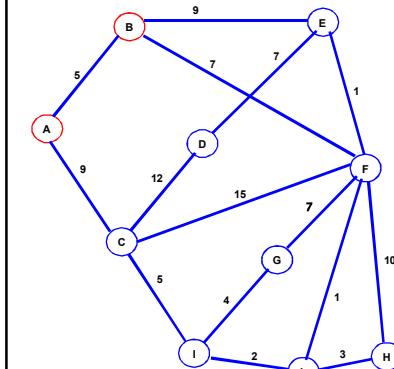
Reti di Calcolatori - 110

Dijkstra



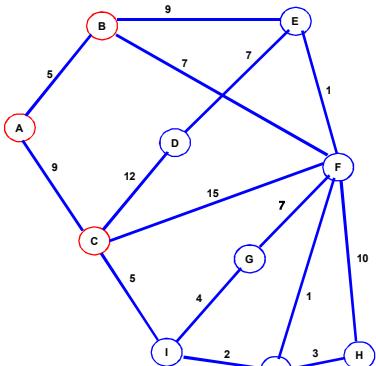
Reti di Calcolatori - 111

Dijkstra



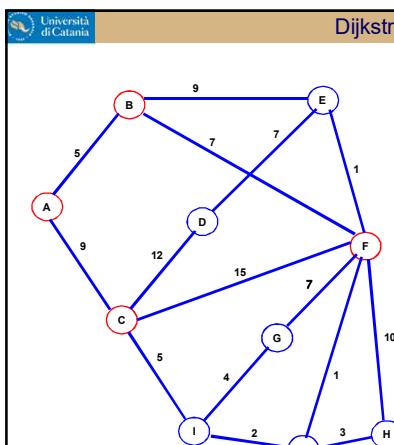
Reti di Calcolatori - 112

Dijkstra

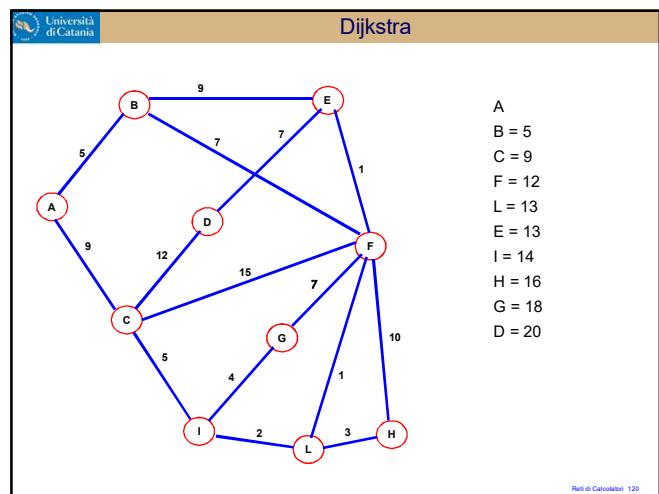
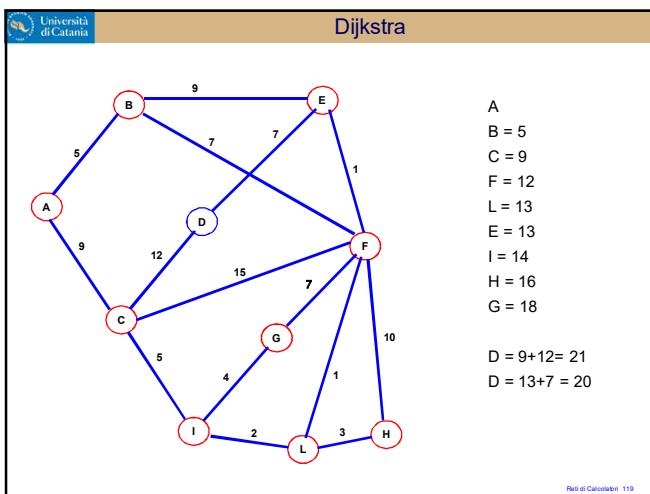
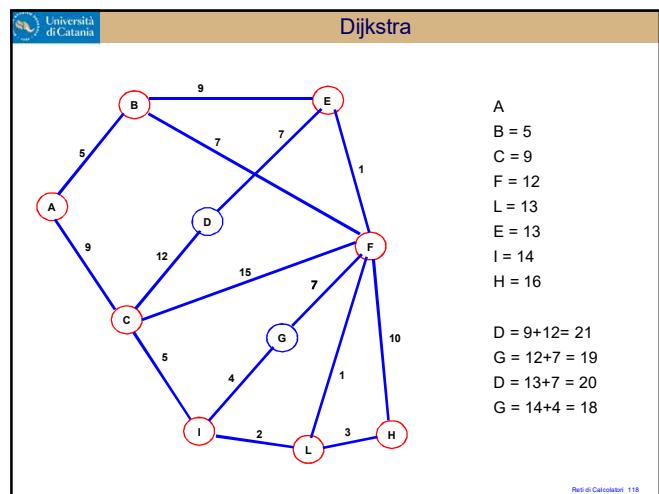
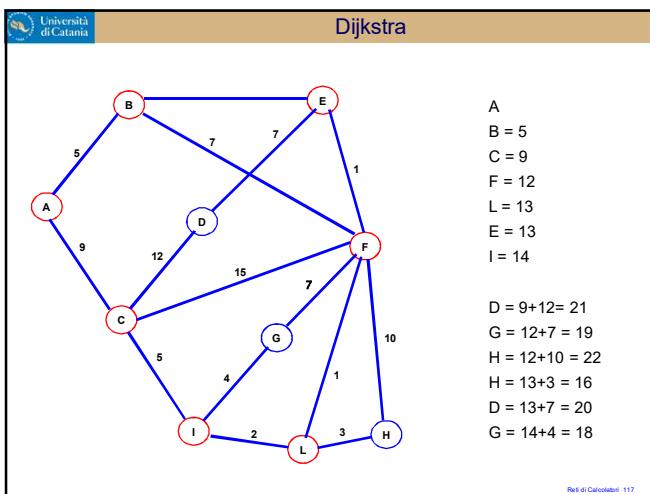
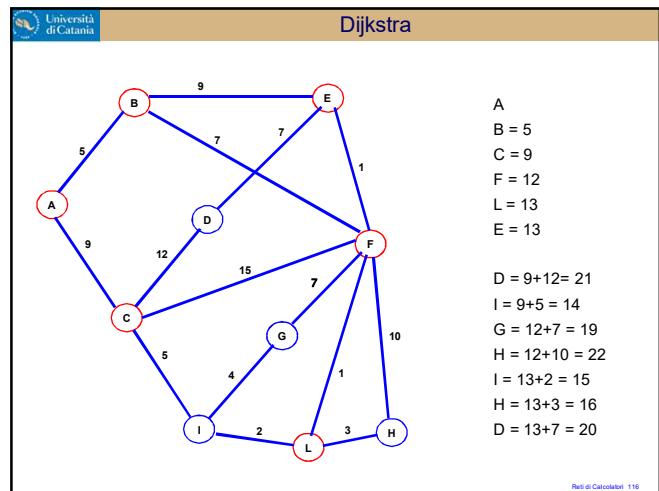
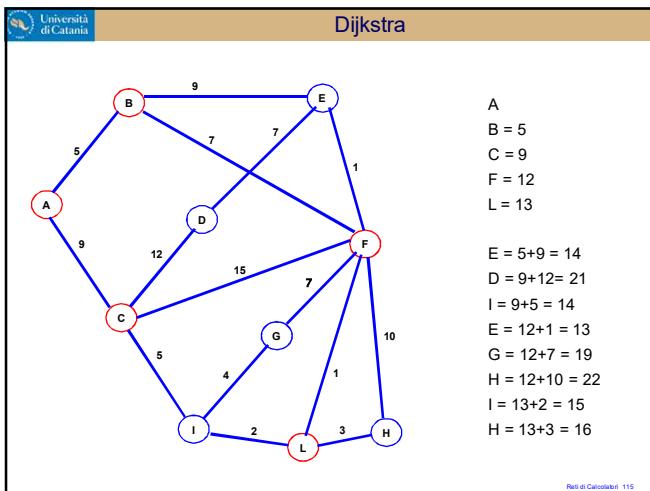


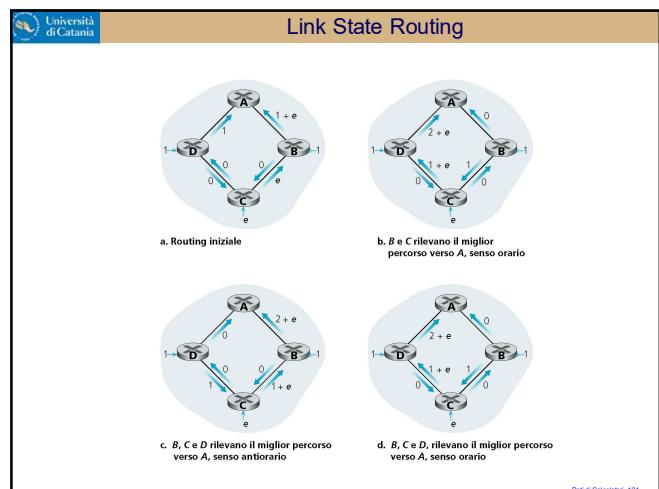
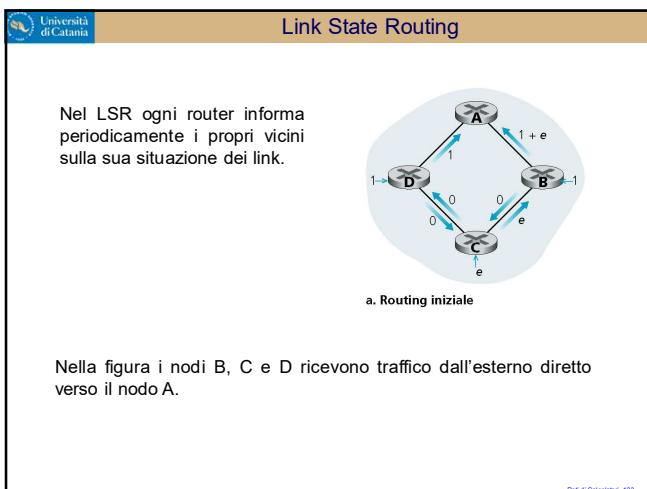
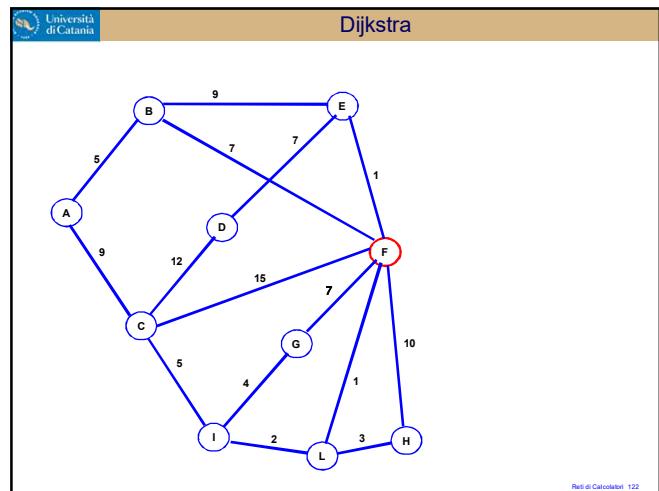
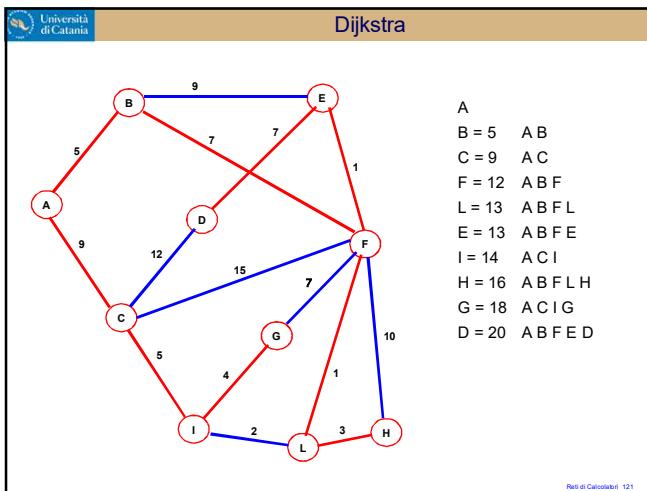
Reti di Calcolatori - 113

Dijkstra



Reti di Calcolatori - 114





Confronto tra DV e LSR

DV	LSR
Decentralizzato	Globale
Messaggi solo per i vicini	Messaggi in Broadcast
Informazioni riguardanti tutte le destinazioni	Informazioni riguardanti solo i propri link
Conteggio all'infinito	Problemi di sincronia (oscillazioni)
Messaggi solo per variazioni sui link	Maggiore traffico di messaggi (invii periodici)
Poco robusto nei confronti di nodi maliziosi	Robusto agli attacchi

Reti di Calcolo lab 125

Internet Routing

Principi base:

- routing dinamico
- Intra-AS e Inter-AS routing

Internet è organizzata in "autonomous systems" (AS).

AS definition: unit of routing policy, either a single network or a group of networks that is controlled by a common network administrator on behalf of a single administrative entity (such as a university, a business enterprise, or a business division)

Ogni AS è internamente fortemente connessa.

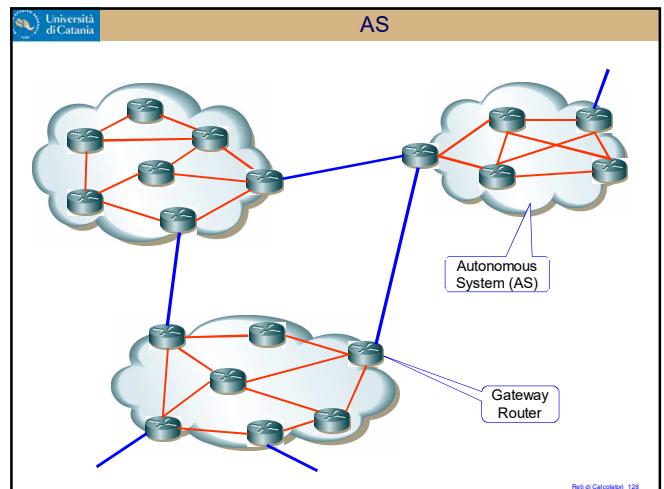
Reti di Calcolo lab 126

Internet Routing

Protocolli:

- Interior Gateway Protocols (IGPs) all'interno di AS (RIP, OSPF, HELLO, IS-IS)
- Exterior Gateway Protocols (EGPs) tra AS (EGP, BGP-4)

Reti di Calcolatori - 127



RIP

Routing Information Protocol:

- RIP v1 (RFC 1058)
- RIP v2 (RFC 1723, 2453).

Basato su **Distance Vector**.
Metrica utilizzata: **HOP** (numero di salti effettuati)

Reti di Calcolatori - 129

RIP v1

Il numero **massimo di HOP** ammesso è **15**: con reti troppo estese la convergenza risulterebbe lenta.
Oltre tale valore il router è considerato irraggiungibile.

Le **Routing Table** (RT) vengono scambiate ogni 30 secondi.
Se un percorso per un router **non viene aggiornato** entro 180 secondi, la sua distanza è posta a infinito.
Trascorsi altri 120 secondi (**garbage-collection timer**) il router viene eliminato dalla RT.

Reti di Calcolatori - 130

Messaggi RIP v1

RIP v1 utilizza due tipi di messaggi :

- **REQUEST**: per chiedere informazioni ai nodi adiacenti
- **RESPONSE**: per inviare informazioni di routing

Una **tavella di routing** contiene:

- Indirizzo di destinazione
- Distanza dalla destinazione (in hop)
- Next hop: router adiacente a cui inviare i pacchetti
- Timeout
- Garbage-collection timer

Reti di Calcolatori - 131

Datagrammi RIP v1

Lunghezza variabile fino a 512 byte (max 25 reti di destinazione).

Command	Version	Must Be Zero
Address Family Identifier		Must Be Zero
IP Address		
		Must Be Zero
		Must Be Zero
		Metric

Command : 1 = richiesta, 2= aggiornamento.
Version : versione del protocollo.
Address Family Identifier : sempre 2 per il protocollo IP
IP Address : indirizzo di destinazione (rete o sottorete)
Metric : hop count (valore compreso tra 1 e 15)

Reti di Calcolatori - 132

RIP v2



Caratteristiche di RIP v2

- Indirizzamento **CIDR** e **VLSM**
- Autenticazione** dei messaggi
- Specifica del **next hop**
- Split horizon, poison reverse**

Reti di Calcolatori - 133

Datagrammi RIP v2

Command	Version	0000
0xFFFF		Autentication Type
Autentication		
Address Family Ident.	Route Tag	
IP Address		
Subnet Mask		
Next Hop		
Metric		

Command : 1 = richiesta, 2= aggiornamento.

Version : versione del protocollo.

Address Family Identifier : sempre 2 per il protocollo IP

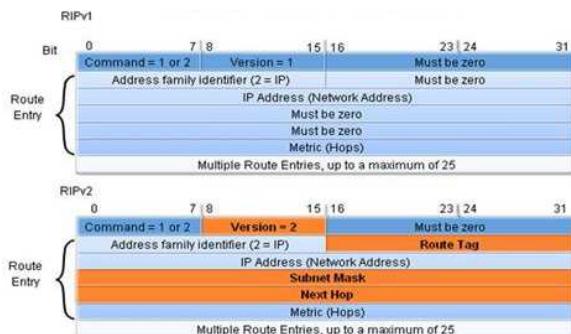
Route Tag: identificazione di route esterni

IP Address : indirizzo di destinazione (rete o sottorete)

Metric : hop count (valore compreso tra 1 e 15)

Reti di Calcolatori - 134

Datagrammi RIP v2



Reti di Calcolatori - 135

RIPng

Command	Version	0000
IPv6 Prefix		
Route Tag	Prefix len.	Metric
...		

RIPng è basato su RIPv2, ma non ne rappresenta un'estensione.
È pensato esclusivamente per IPv6 (non supporta IPv4).

RIPng ha le stesse caratteristiche di RIPv2 tranne l'autenticazione

Reti di Calcolatori - 136

OSPF

Open Shortest Path First

- OSPFv1 (RFC 1131);
- OSPFv2 (RFC 2178, 2328).

- Pensato per sostituire RIP
- Si basa sul Link State Routing
- Va bene per reti di dimensioni grandi
- I messaggi sono autenticati
- Consente l'utilizzo di metriche differenti

Reti di Calcolatori - 137

OSPF

Il protocollo **OSPF** si compone di tre parti:

- HELLO**: scoperta e verifica dei vicini
- EXCHANGE**: sincronizzazione iniziale del DB
- FLOODING**: aggiornamento del DB

Reti di Calcolatori - 138

Database di Link State

Ogni router ha un database composto da "link state record"

I vari DB vengono aggiornati e sincronizzati tramite i "Link State Advertisement" (LSA).

Gli LSA sono emessi:

- quando un router riscontra un nuovo router adiacente
- quando un router – link si guasta
- quando il costo di un link cambia
- periodicamente, tipicamente ogni 30 minuti

Rete di Calcolatori - 139

Link State Advertisement

LS Age	Options	Ls Type
Link State ID		
Advertisement Router		
Link State Sequence Number		
Link State Checksum	Lenght	
LS Data		

Rete di Calcolatori - 140

Header comune OSPF

Version	Type	Message Length
	Router ID	
	Area ID	
Checksum	Autentication Type	
	Autentication Data	
Rest of the OSPF Message		

Type:

1. Hello
 2. DB Description
 3. LS Request
 4. LS Update
 5. LS ACK
- Router ID: router che ha generato il messaggio
AreaID: Ip dell'area a cui si riferisce il messaggio

Rete di Calcolatori - 141

Tipi di datagrammi OSPF

Hello: Trasmissione periodica per la scoperta dei vicini

Database Description: usato per lo scambio dell'informazione dei Link-State di ogni router

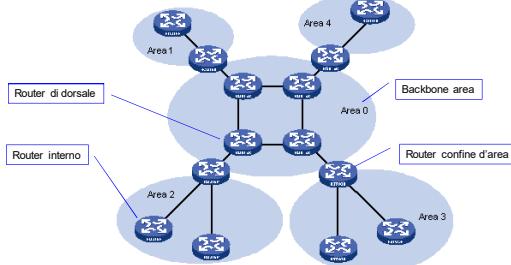
LS Request: richiesta di parti specifiche del database di Link-State di un vicino

Link-State Update: trasferisce annunci di link-state ai vicini

Link-State Acknowledgments: invia una conferma di ricezione di un update di link-state

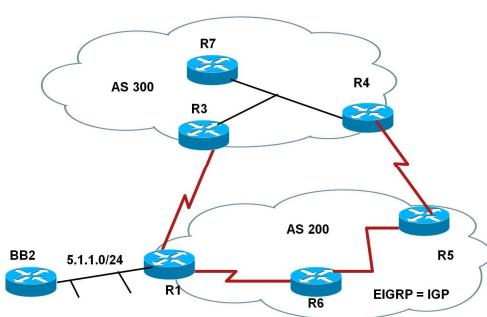
Rete di Calcolatori - 142

OSPF

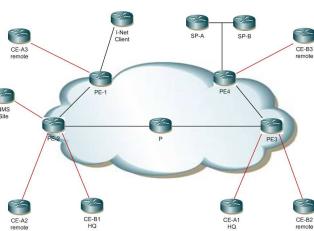


Rete di Calcolatori - 143

BGP v4



Rete di Calcolatori - 144

BGP

- **AS Border Router (ASBR):** router connesso ad altri sistemi autonomi
- **BGP speaker:** router che supporta il protocollo BGP (un BGP speaker non necessariamente coincide con un AS border router)
- **BGP Neighbors:** coppia di BGP speaker che si scambiano informazioni di instradamento inter-AS
 - interni: se appartengono allo stesso AS
 - esterni: se appartengono ad AS diversi