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7 – Protocols

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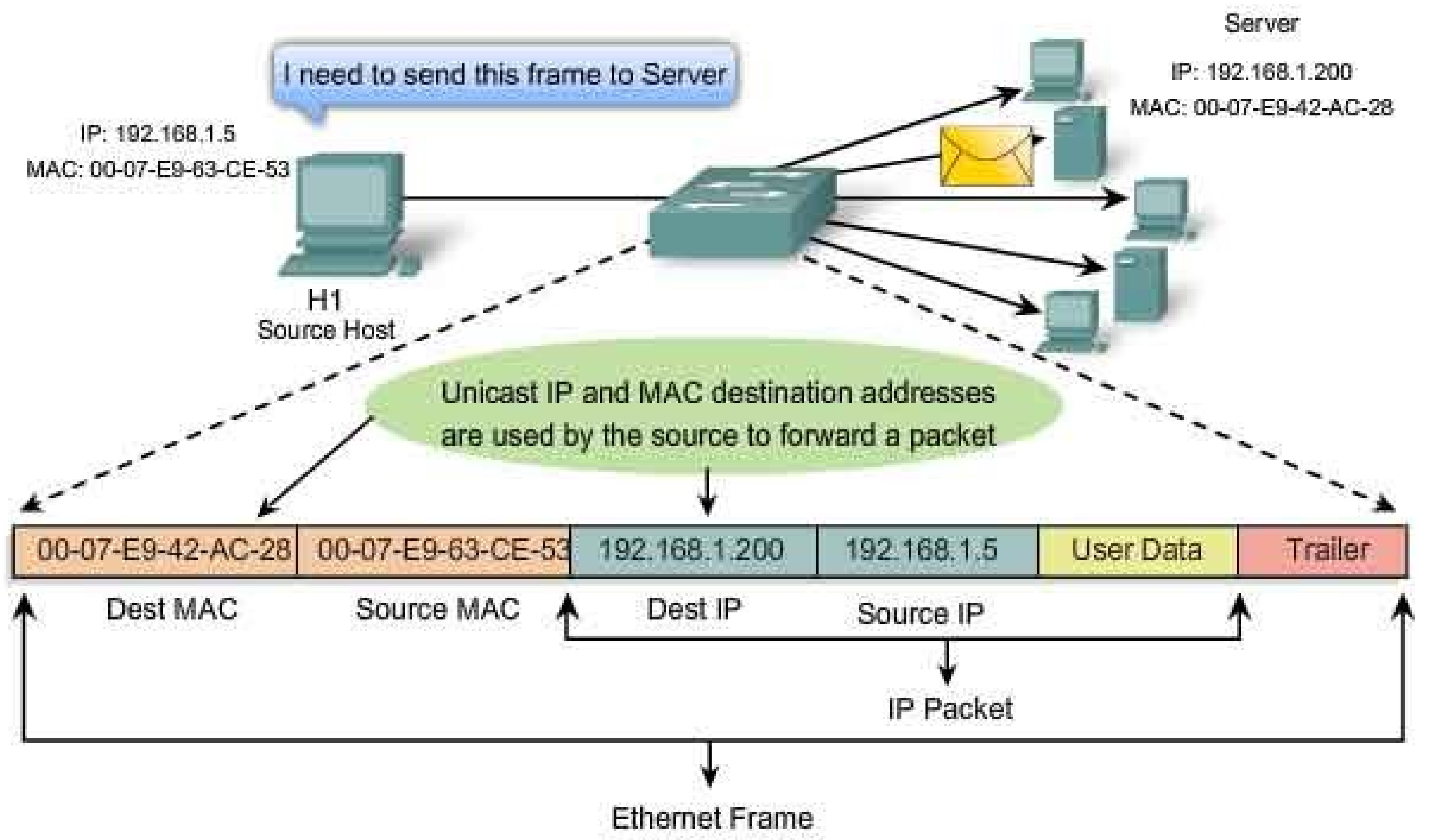
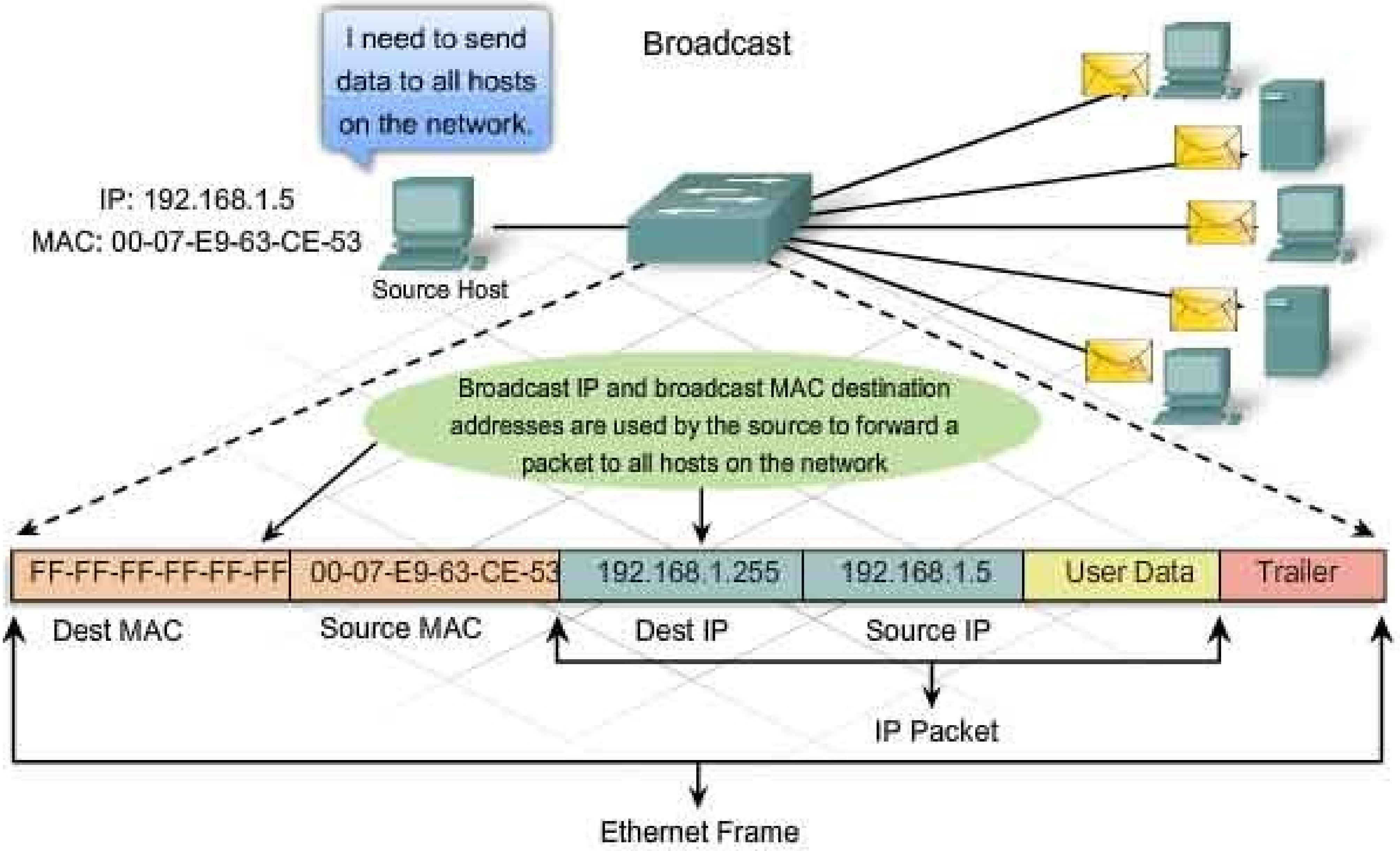
- ARP/RARP
- ICMP
- UDP
- TCP
- TCP Congestion
- SCTP
- DCCP
- DNS

Type of requests - Unicast



Type of requests - Broadcast



Broadcast IP and broadcast MAC destination addresses are used by the source to forward a packet to all hosts on the network

FF-FF-FF-FF-FF-FF	00-07-E9-63-CE-53	192.168.1.255	192.168.1.5	User Data	Trailer
Dest MAC	Source MAC	Dest IP	Source IP		

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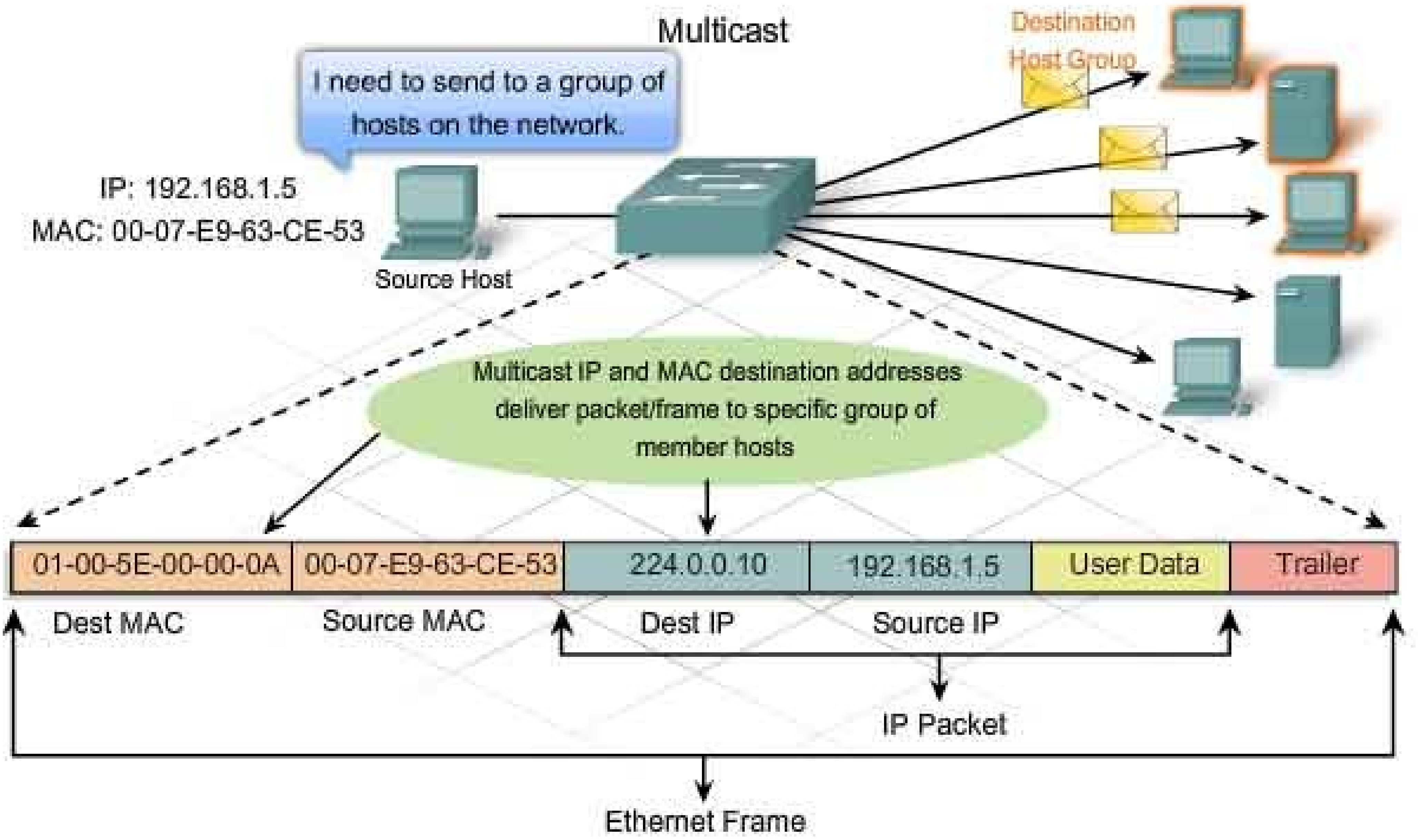
Type of requests - Multicast

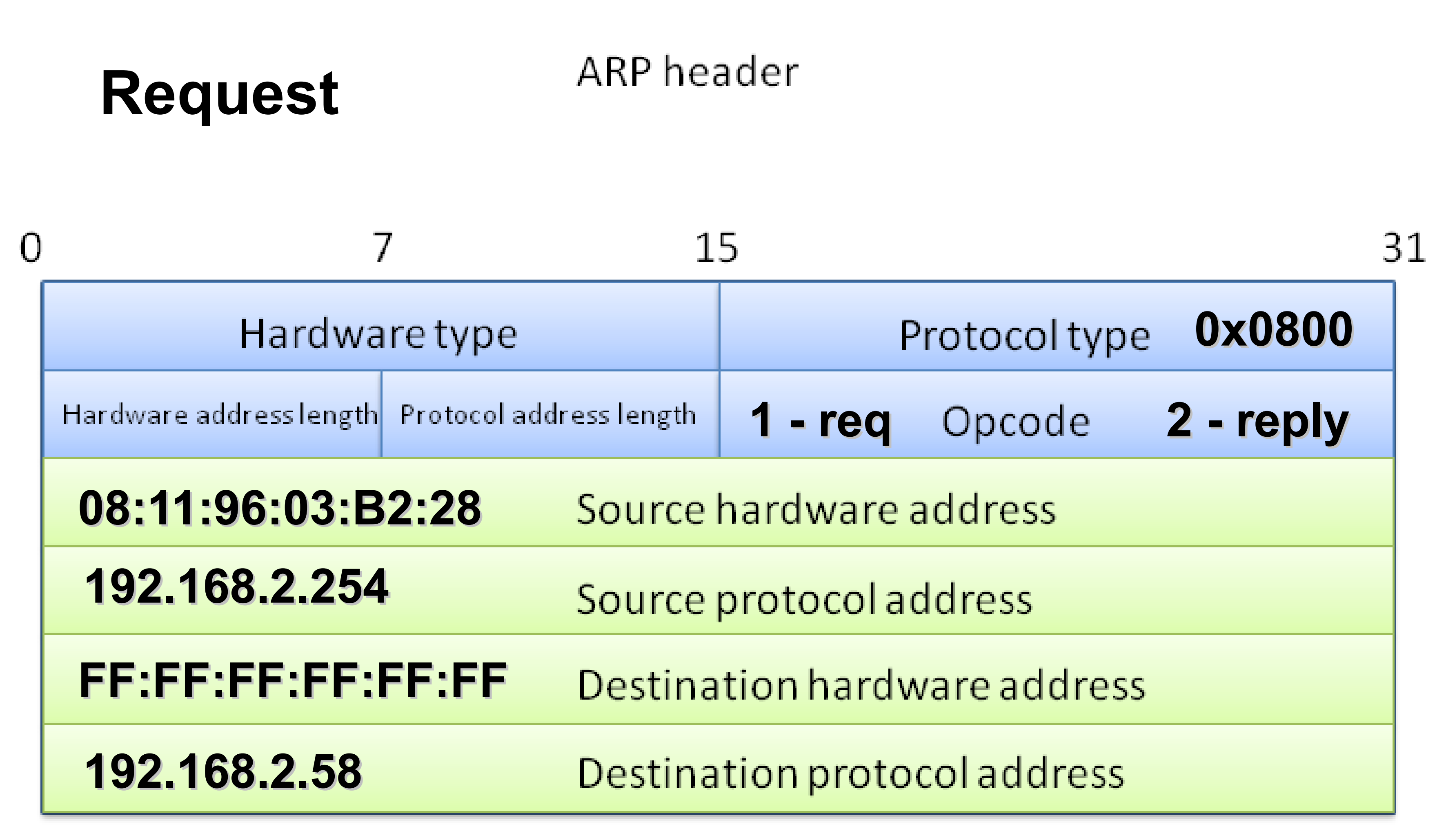


Address Resolution Protocol

- Address resolution
  - Forward
  - Reverse
- ARP
  - Probe
  - Proxy
  - Mediation
  - Stuffing

Address Resolution Protocol

- Address resolution
  - Forward (what is the MAC of this machine)



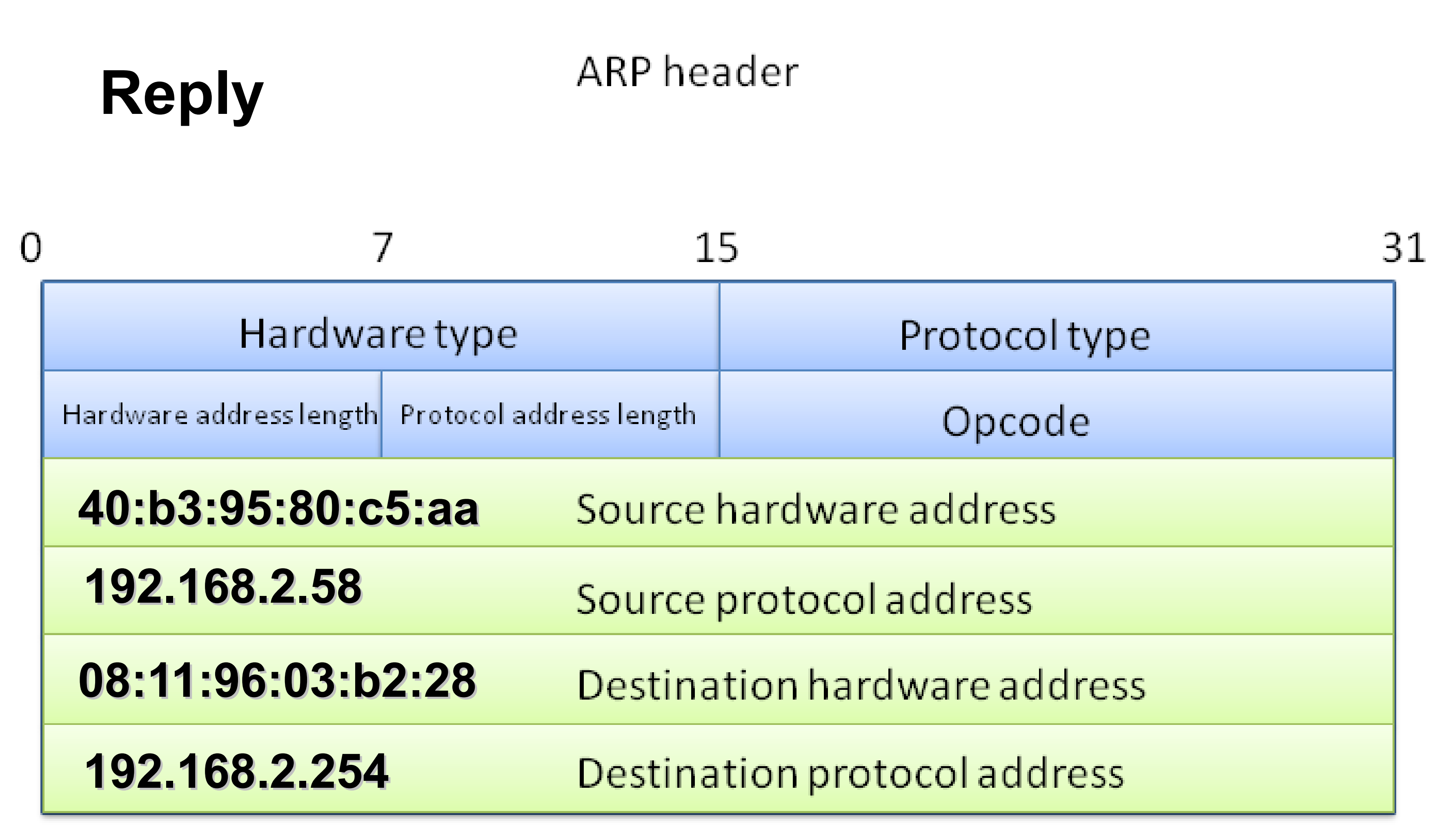
Request

ARP header

<table>
<tr><th>0</th><th>7</th><th>15</th><th>31</th></tr>
<tr><td colspan="2">Hardware type</td><td colspan="2">Protocol type **0x0800**</td></tr>
<tr><td>Hardware address length</td><td>Protocol address length</td><td colspan="2">**1 - req** Opcode **2 - reply**</td></tr>
<tr><td colspan="4">**08:11:96:03:B2:28** Source hardware address</td></tr>
<tr><td colspan="4">**192.168.2.254** Source protocol address</td></tr>
<tr><td colspan="4">**FF:FF:FF:FF:FF:FF** Destination hardware address</td></tr>
<tr><td colspan="4">**192.168.2.58** Destination protocol address</td></tr>
</table>

Address Resolution Protocol

- Address resolution
  - Forward (what is the MAC of this machine)



Reply

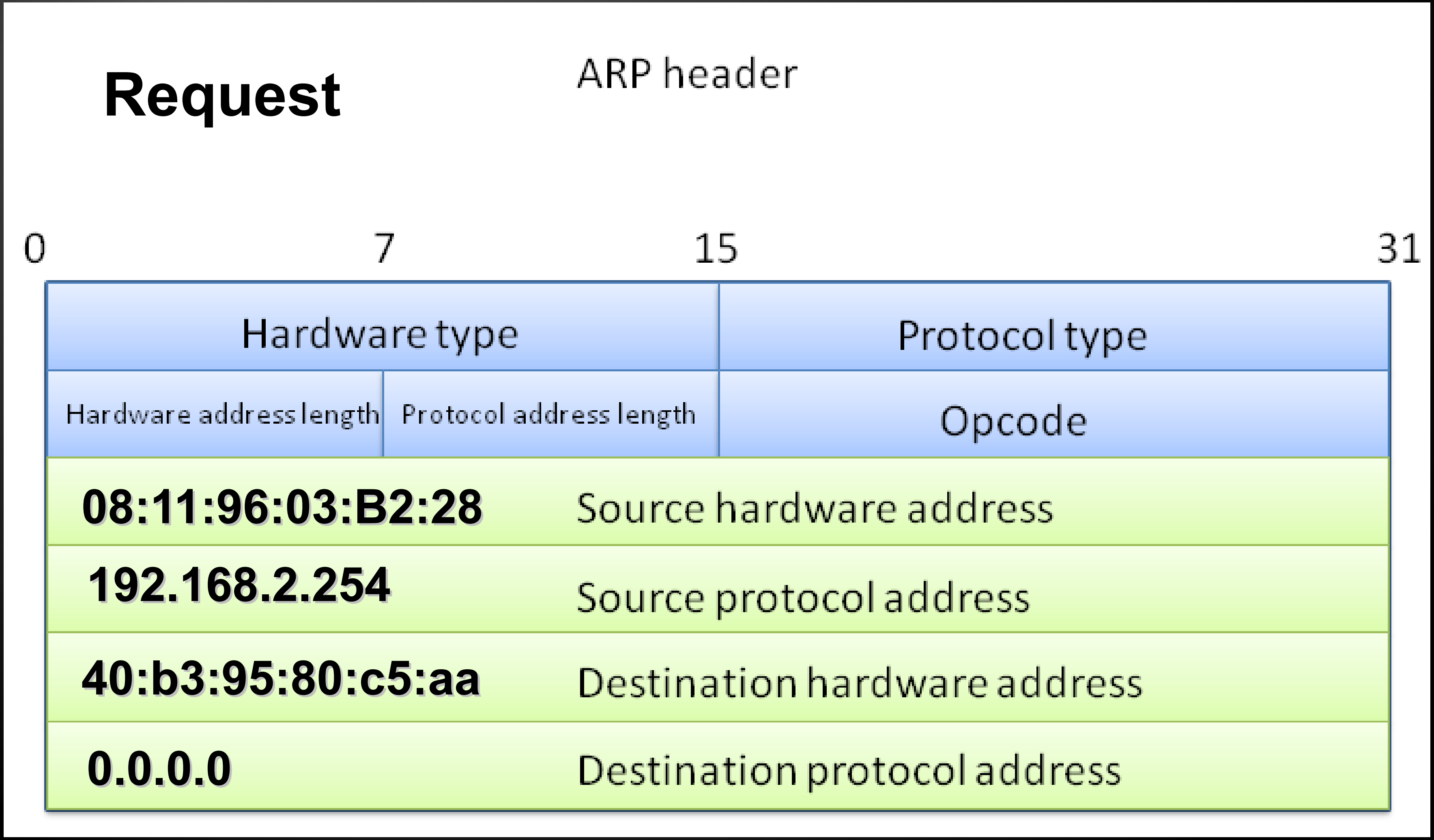
ARP header

0 7 15 31

Hardware type		Protocol type
Hardware address length	Protocol address length	Opcode
40:b3:95:80:c5:aa	Source hardware address	
192.168.2.58	Source protocol address	
08:11:96:03:b2:28	Destination hardware address	
192.168.2.254	Destination protocol address	

Address Resolution Protocol

- Address resolution
  - Reverse (what is the IP of this machine)



Request

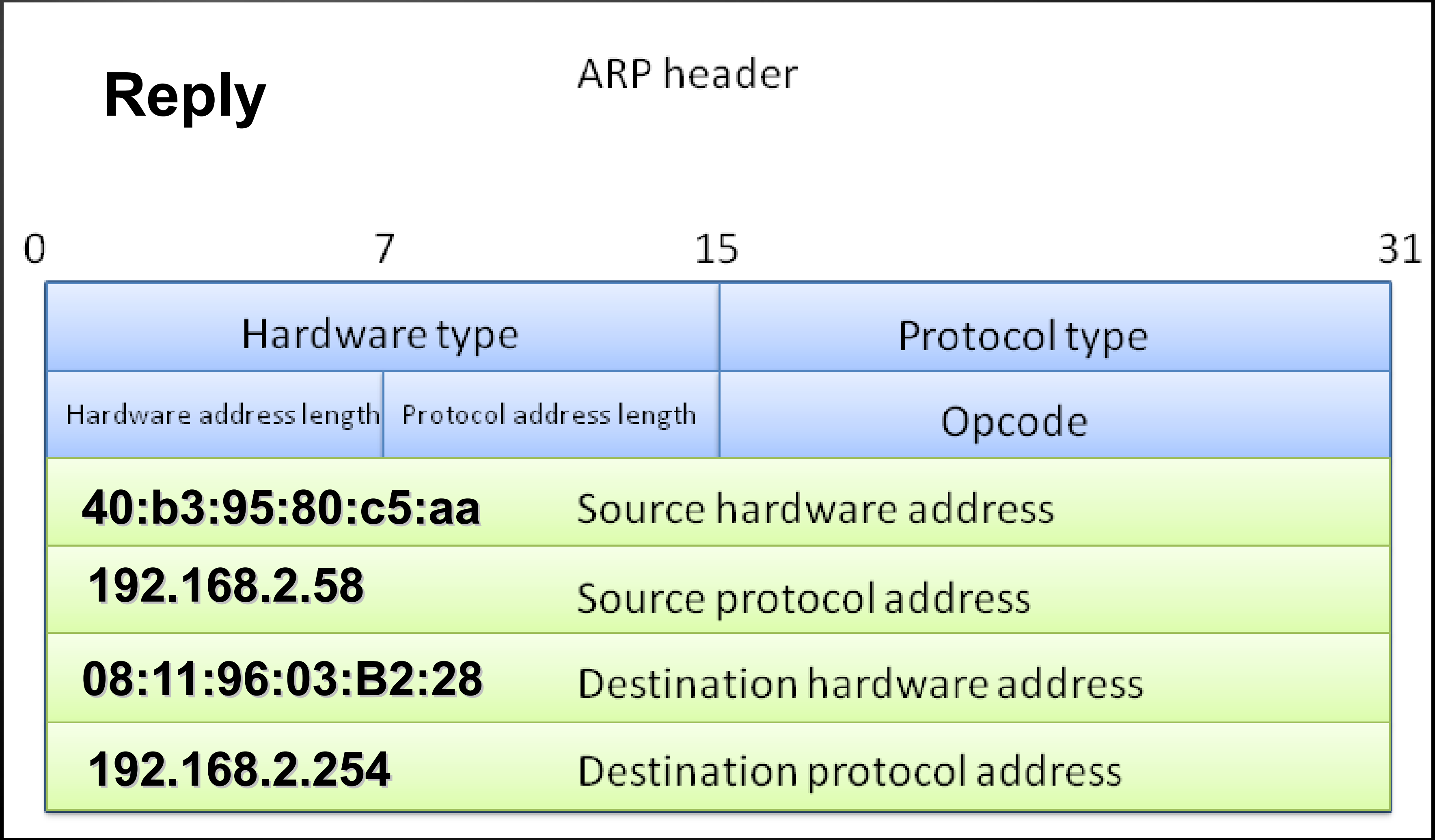
ARP header

0 7 15 31

Hardware type		Protocol type
Hardware address length	Protocol address length	Opcode
08:11:96:03:B2:28	Source hardware address	
192.168.2.254	Source protocol address	
40:b3:95:80:c5:aa	Destination hardware address	
0.0.0.0	Destination protocol address	

Address Resolution Protocol

- Address resolution
  - Reverse (what is the IP of this machine)



Reply

ARP header

0 7 15 31

Hardware type		Protocol type
Hardware address length	Protocol address length	Opcode
40:b3:95:80:c5:aa	Source hardware address	
192.168.2.58	Source protocol address	
08:11:96:03:B2:28	Destination hardware address	
192.168.2.254	Destination protocol address	

Address Resolution Protocol

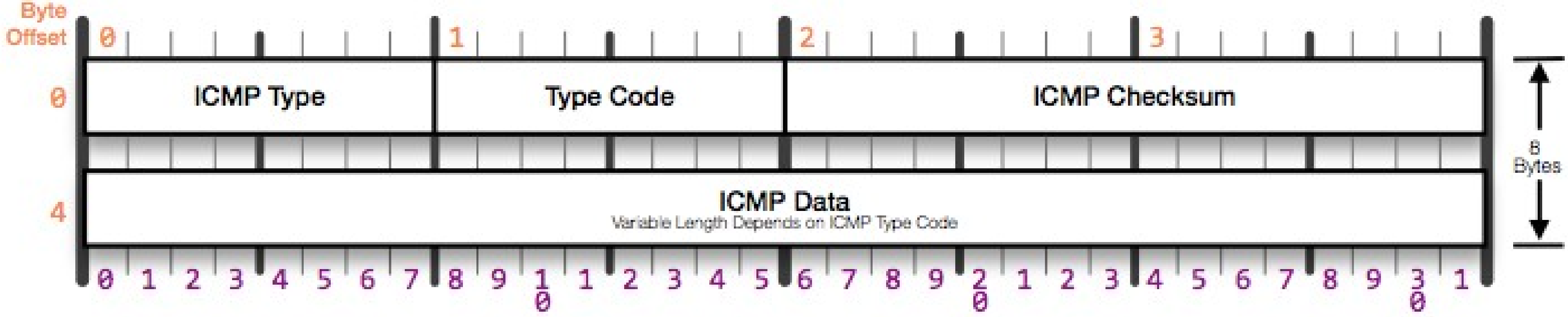
- How it actually looks

```
15:12:43.772954 ARP, Ethernet (len 6), IPv4 (len 4),
Request who-has 192.168.2.58 tell 192.168.2.254, length 28
15:12:43.962834 ARP, Ethernet (len 6), IPv4 (len 4),
Reply 192.168.2.58 is-at 40:b3:95:80:c5:aa, length 46
```

- ARP probe
- ARP proxy
- ARP mediation
- ARP stuffing

ICMP Header

RFC 792 Outlines the ICMP Protocol



Byte Offset	0	1	2	3
0	ICMP Type	Type Code	ICMP Checksum	
4	ICMP Data Variable Length Depends on ICMP Type Code			

🟩 ICMP Type

0 Echo Reply

🟥 ICMP Type

3 Destination Unreachable

Type Code	
0	Network Unreachable
1	Host Unreachable
2	Protocol Unreachable
3	Port Unreachable
4	Fragment Necessary
5	Source Route Failed
6	Destination Network Unknown
7	Destination Host Unknown
8	Obsolete
9	Destination Network Prohibited
10	Destination Host Prohibited
11	Network Unreachable for TOS
12	Host Unreachable for TOS
13	Communication Prohibited

🟥 ICMP Type

4 Source Quench

🟥 ICMP Type

5 Redirect

Type Code	
0	Redirect for Network
1	Redirect for Host
2	Redirect for TOS and Network
3	Redirect for TOS and Host

🟩 ICMP Type

8 Echo Request

🟩 ICMP Type

9 Router Advertisement

🟩 ICMP Type

10 Router Solicitation

🟥 ICMP Type

11 Time to Live Exceeded

Type Code	
0	TTL Exceeded in Transit
1	TTL Exceeded in Reassembly

🟥 ICMP Type

12 Parameter Problem

Type Code	
0	Pointer Problem
1	Required Option Missing

🟩 ICMP Type

13 Timestamp Request

🟩 ICMP Type

14 Timestamp Reply

🟩 ICMP Type

17 Address Mask Request

🟩 ICMP Type

18 Address Mask Reply

🟩 ICMP QUERY OR RESPONSE

🟥 ICMP ERROR MESSAGE

ICMP Protocol Header Format

Created by Troy Jessup - http://www.troyjessup.com

Internet Control Message Protocol - ICMP

- ICMP types
  - 0 – Echo replay
  - 1,2 – Reserved
  - 3 – Destination unreachable
  - 8 – Echo request
  - 9 – TTL Exceeded
  - 30 – Traceroute

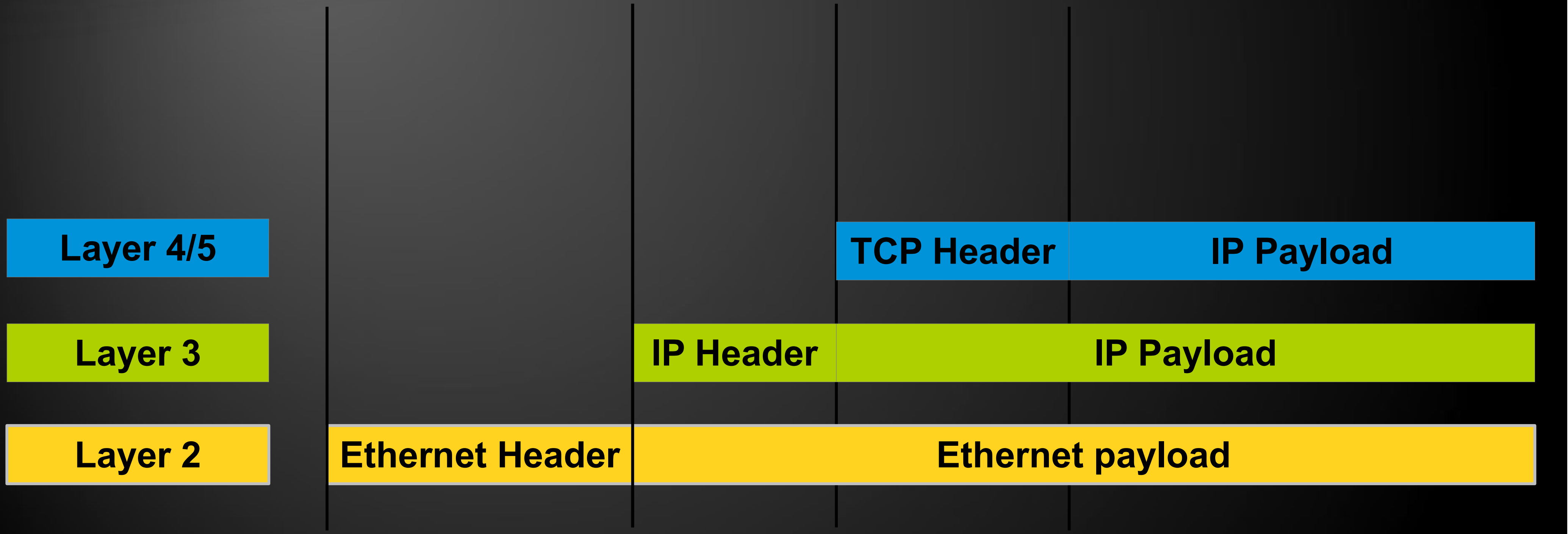
Internet Control Message Protocol - ICMP

- Type codes

11 – Time to live exceeded
- 0 – in transit
- 1 – in reassembly

3 – Destination unreachable
- 0 – network unreachable
- 1 – host unreachable
- 2 – protocol unreachable
- 3 – port unreachable
- 6 – network unknown
- 7 – host unknown
- 9 – network prohibited
- 10 – host prohibited

Protocol Encapsolation



Layer 4/5

TCP Header

IP Payload

Layer 3

IP Header

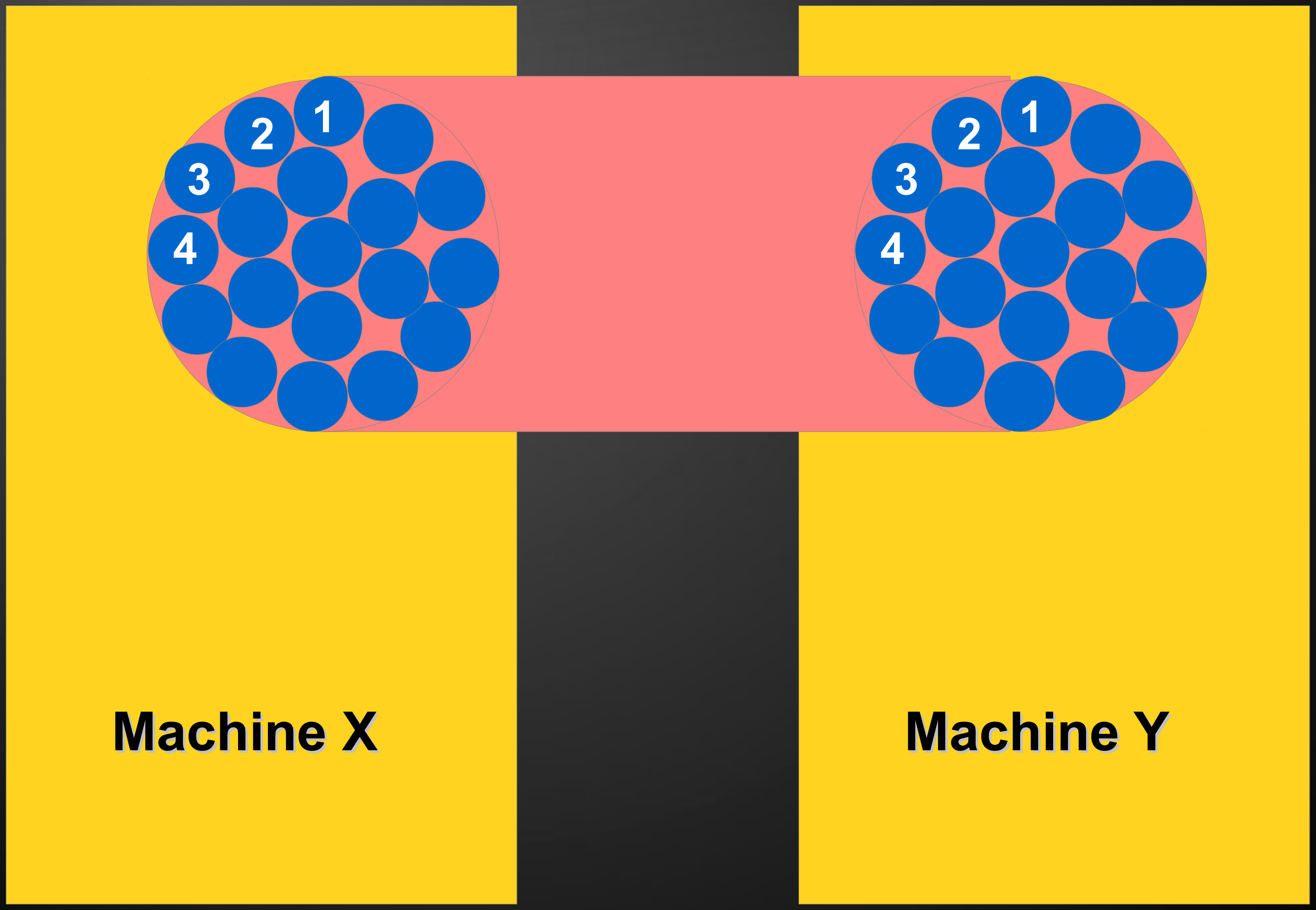
IP Payload

Layer 2

Ethernet Header

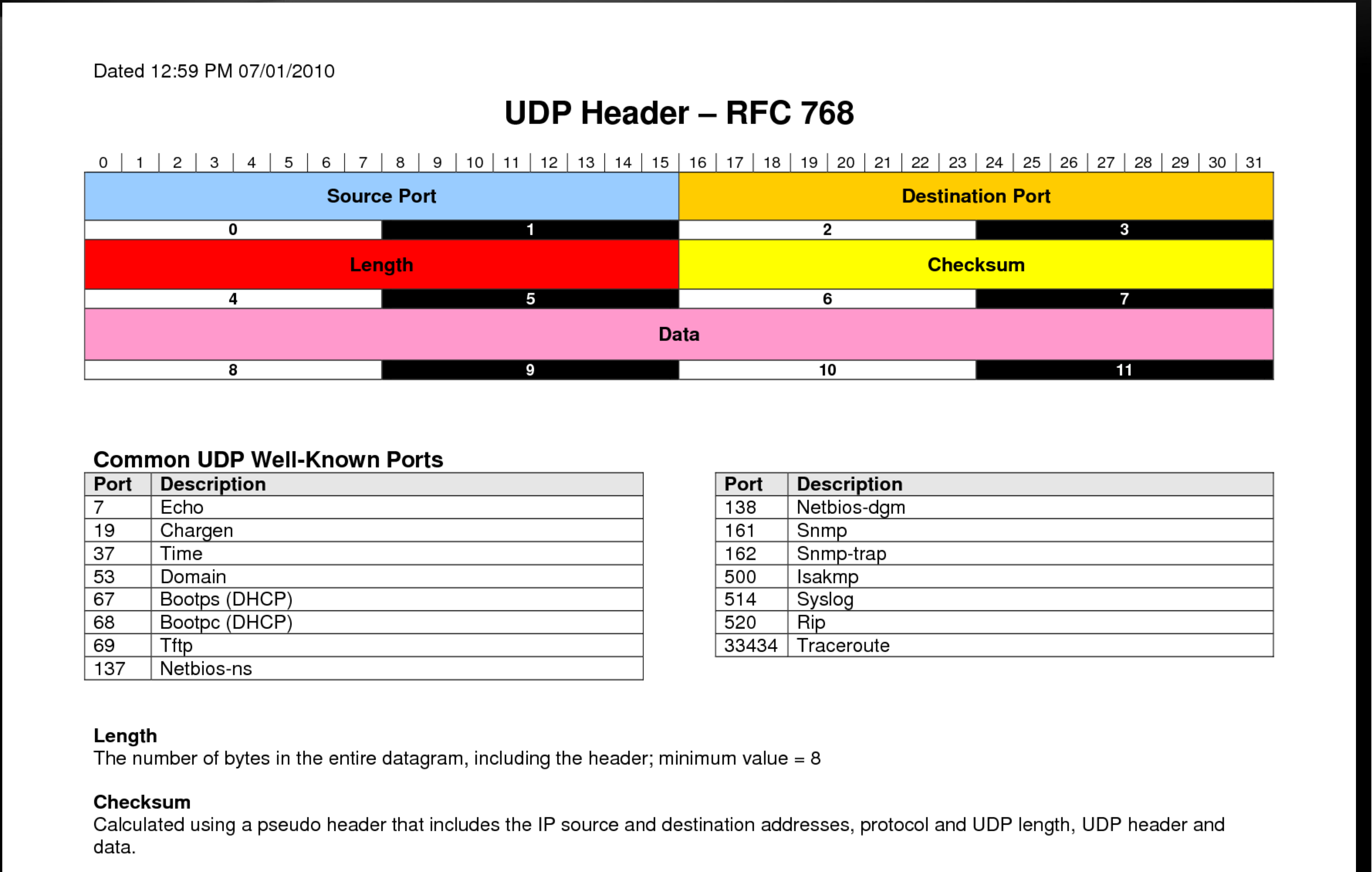
Ethernet payload

User Datagram Protocol - UDP



UDP (RFC768 Jon Postel 1980)

User Datagram Protocol - UDP



Dated 12:59 PM 07/01/2010

UDP Header – RFC 768

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td></tr>
<tr><td colspan="16">Source Port</td><td colspan="16">Destination Port</td></tr>
<tr><td colspan="8">0</td><td colspan="8">1</td><td colspan="8">2</td><td colspan="8">3</td></tr>
<tr><td colspan="16">Length</td><td colspan="16">Checksum</td></tr>
<tr><td colspan="8">4</td><td colspan="8">5</td><td colspan="8">6</td><td colspan="8">7</td></tr>
<tr><td colspan="32">Data</td></tr>
<tr><td colspan="8">8</td><td colspan="8">9</td><td colspan="8">10</td><td colspan="8">11</td></tr>
</table>

Common UDP Well-Known Ports

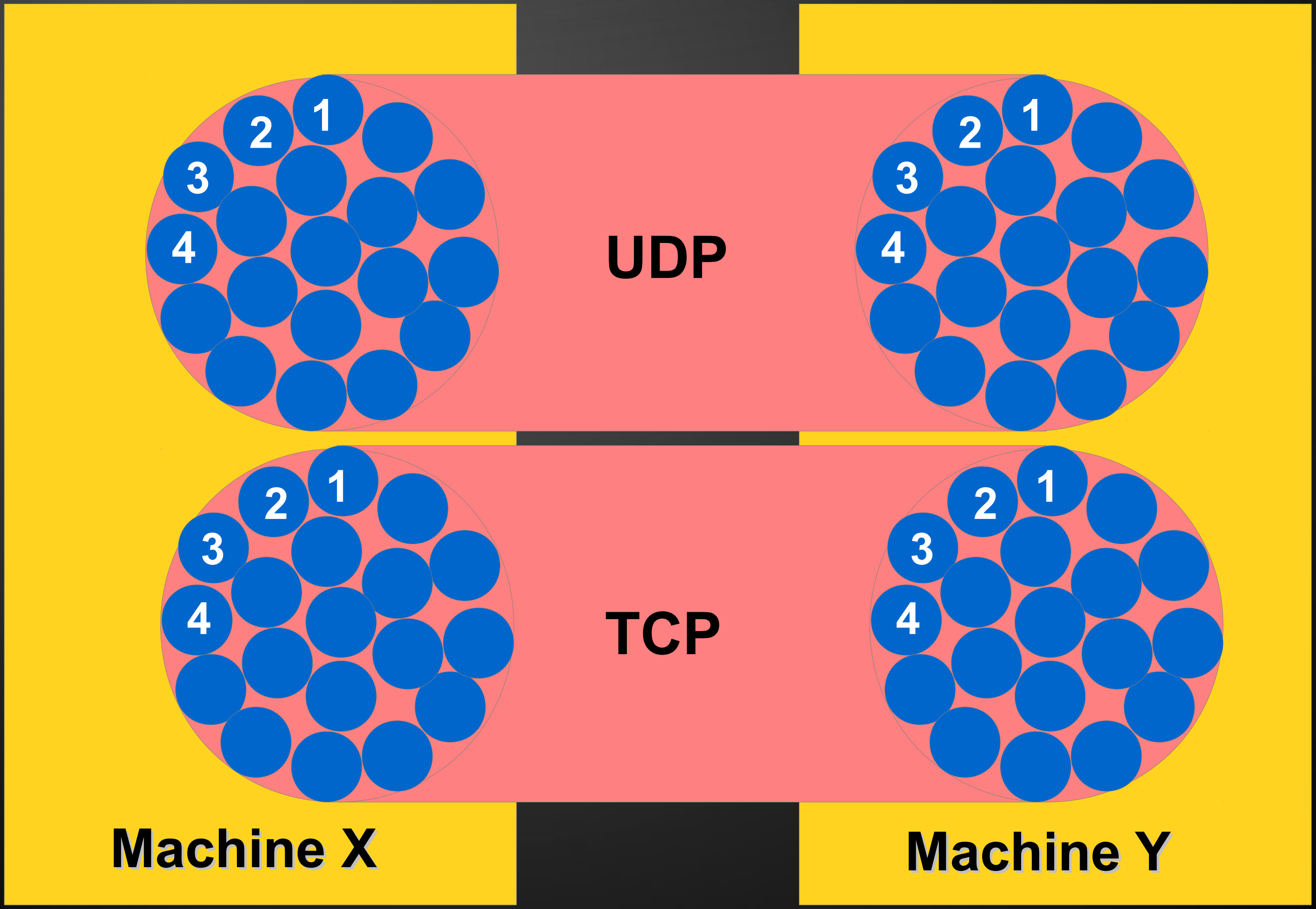
Port	Description
7	Echo
19	Chargen
37	Time
53	Domain
67	Bootps (DHCP)
68	Bootpc (DHCP)
69	Tftp
137	Netbios-ns

Port	Description
138	Netbios-dgm
161	Snmp
162	Snmp-trap
500	Isakmp
514	Syslog
520	Rip
33434	Traceroute

Length
The number of bytes in the entire datagram, including the header; minimum value = 8

Checksum
Calculated using a pseudo header that includes the IP source and destination addresses, protocol and UDP length, UDP header and data.

Transmission Datagram Protocol - TCP



TCP (RFC793 Jon Postel 1981)

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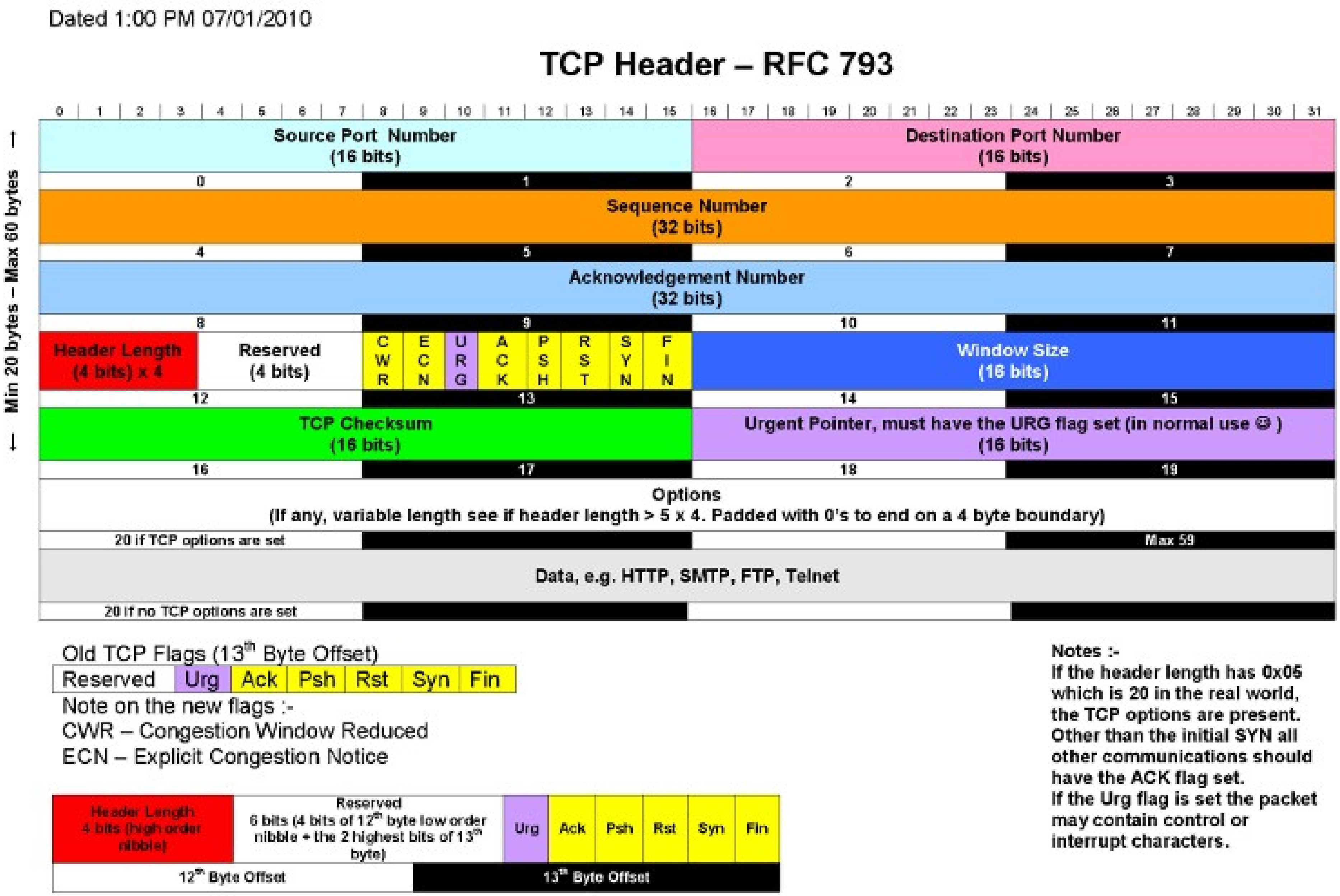
Transmission Datagram Protocol - TCP



Dated 1:00 PM 07/01/2010

TCP Header – RFC 793

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

← Min 20 bytes – Max 60 bytes →

Source Port Number (16 bits) | Destination Port Number (16 bits)

0 | 1 | 2 | 3

Sequence Number (32 bits)

4 | 5 | 6 | 7

Acknowledgement Number (32 bits)

8 | 9 | 10 | 11

Header Length (4 bits) x 4 | Reserved (4 bits) | CWR | ECN | URG | ACK | PSH | RST | SYN | FIN | Window Size (16 bits)

12 | 13 | 14 | 15

TCP Checksum (16 bits) | Urgent Pointer, must have the URG flag set (in normal use ☺) (16 bits)

16 | 17 | 18 | 19

Options
(If any, variable length see if header length > 5 x 4. Padded with 0's to end on a 4 byte boundary)

20 if TCP options are set | Max 59

Data, e.g. HTTP, SMTP, FTP, Telnet

20 if no TCP options are set

Old TCP Flags (13th Byte Offset)

Reserved	Urg	Ack	Psh	Rst	Syn	Fin

Note on the new flags :-
CWR – Congestion Window Reduced
ECN – Explicit Congestion Notice

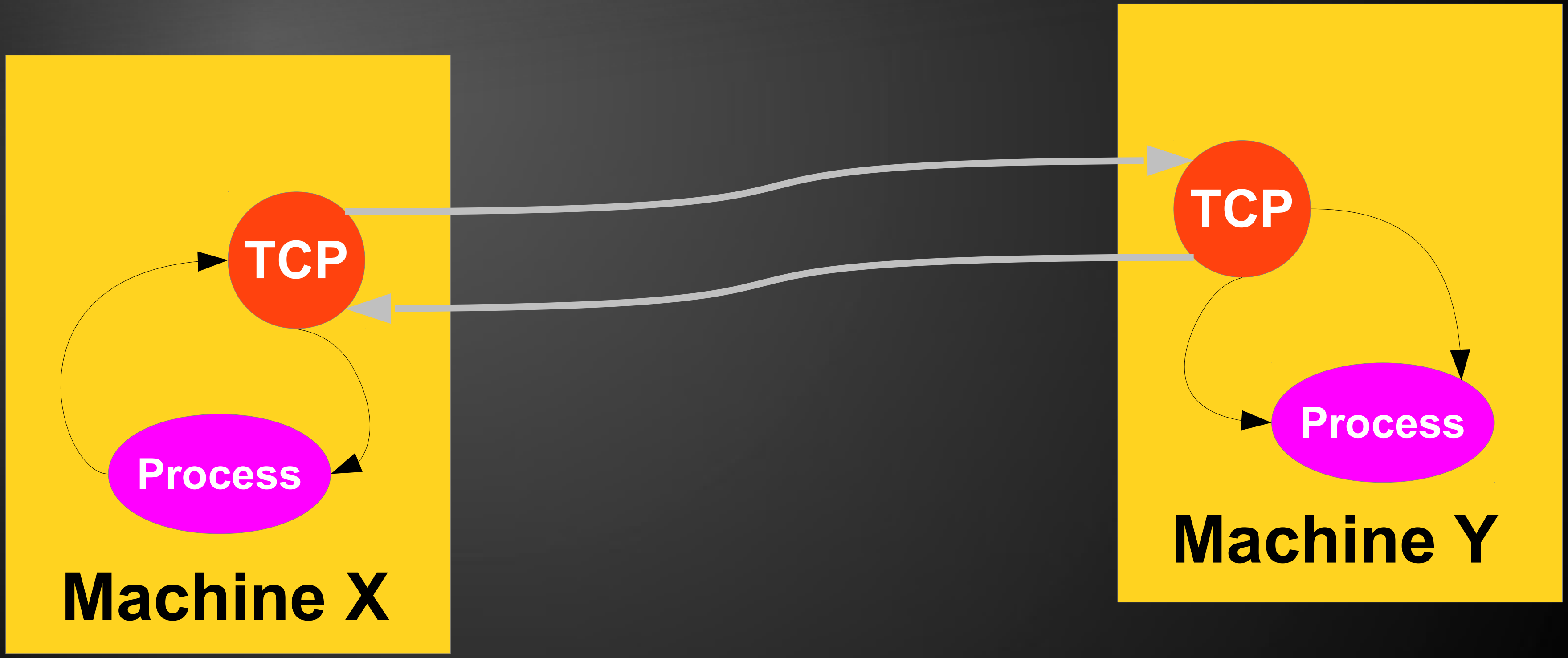
Header Length 4 bits (high order nibble)	Reserved 6 bits (4 bits of 12th byte low order nibble + the 2 highest bits of 13th byte)	Urg	Ack	Psh	Rst	Syn	Fin
12th Byte Offset	13th Byte Offset						

Notes :-
If the header length has 0x05 which is 20 in the real world, the TCP options are present.
Other than the initial SYN all other communications should have the ACK flag set.
If the Urg flag is set the packet may contain control or interrupt characters.

Transmission Datagram Protocol - TCP

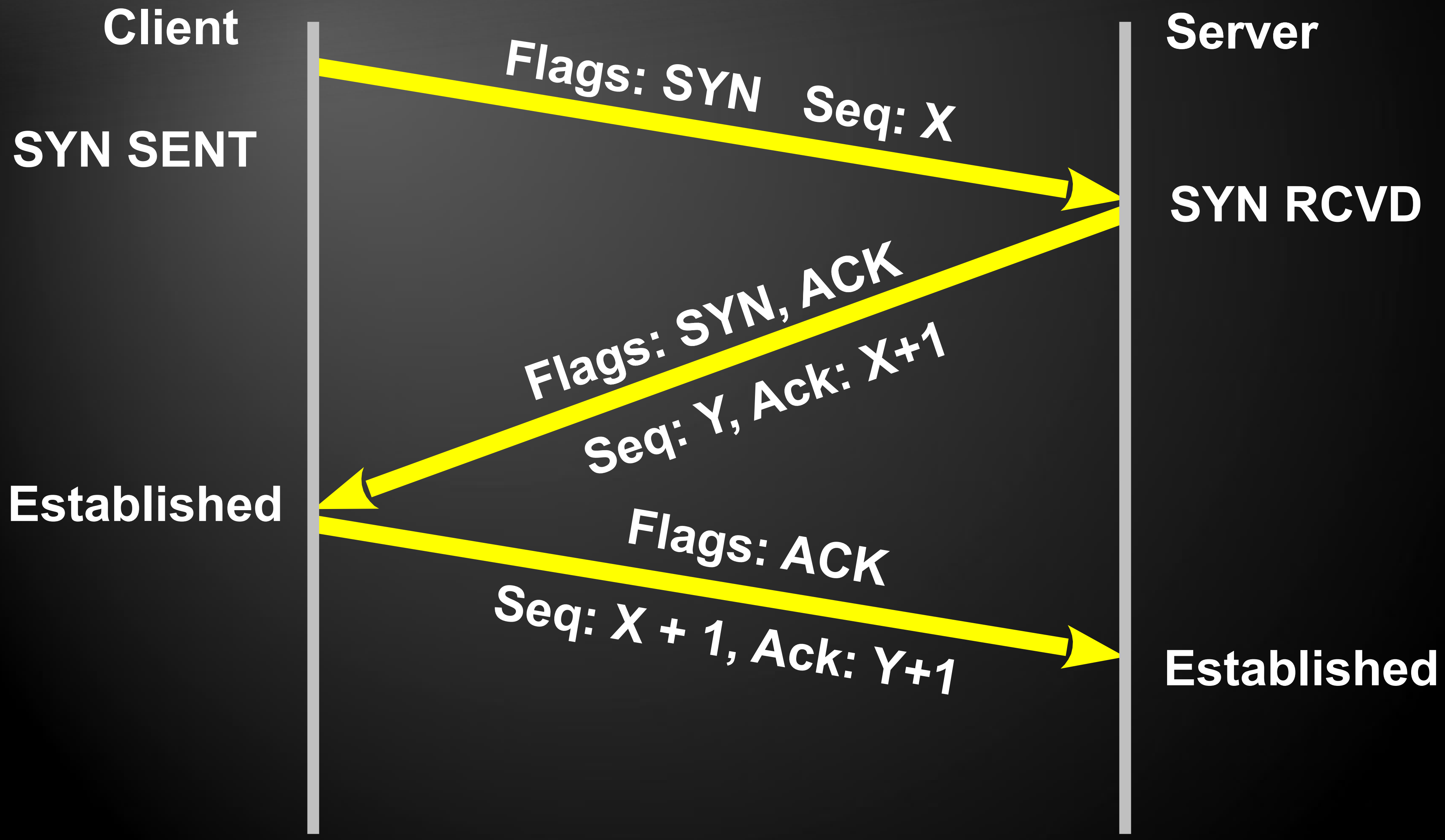
- TCP (RFC793 Jon Postel 1981)
  - Session establishment and tear-down
  - Window procedure
  - Slow start and congestion avoidance (Van Jacobson 1988)
  - Fast open
  - Syn cookies

Transmission Datagram Protocol - TCP



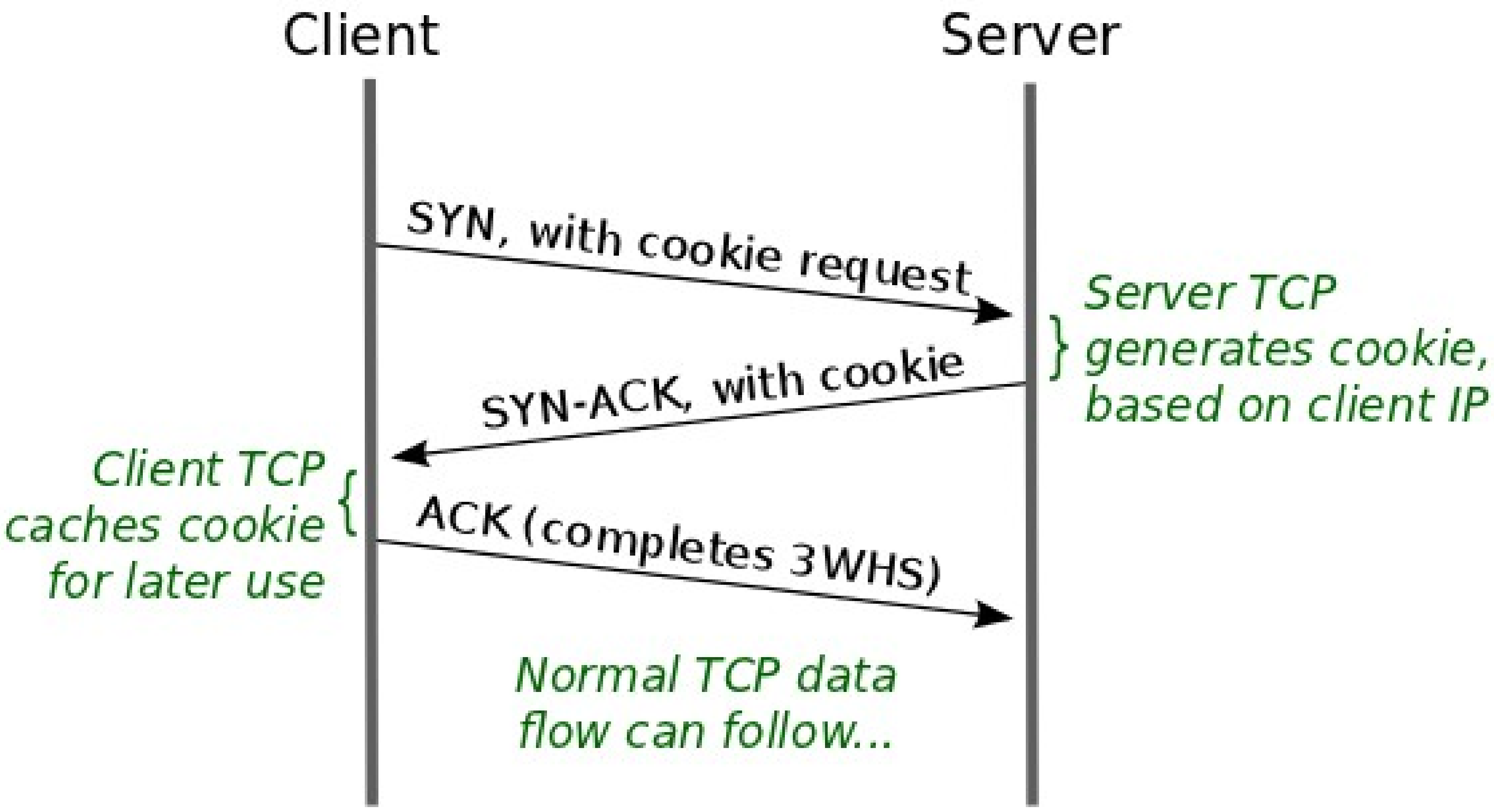
Transmission Datagram Protocol - TCP

Three way handshake



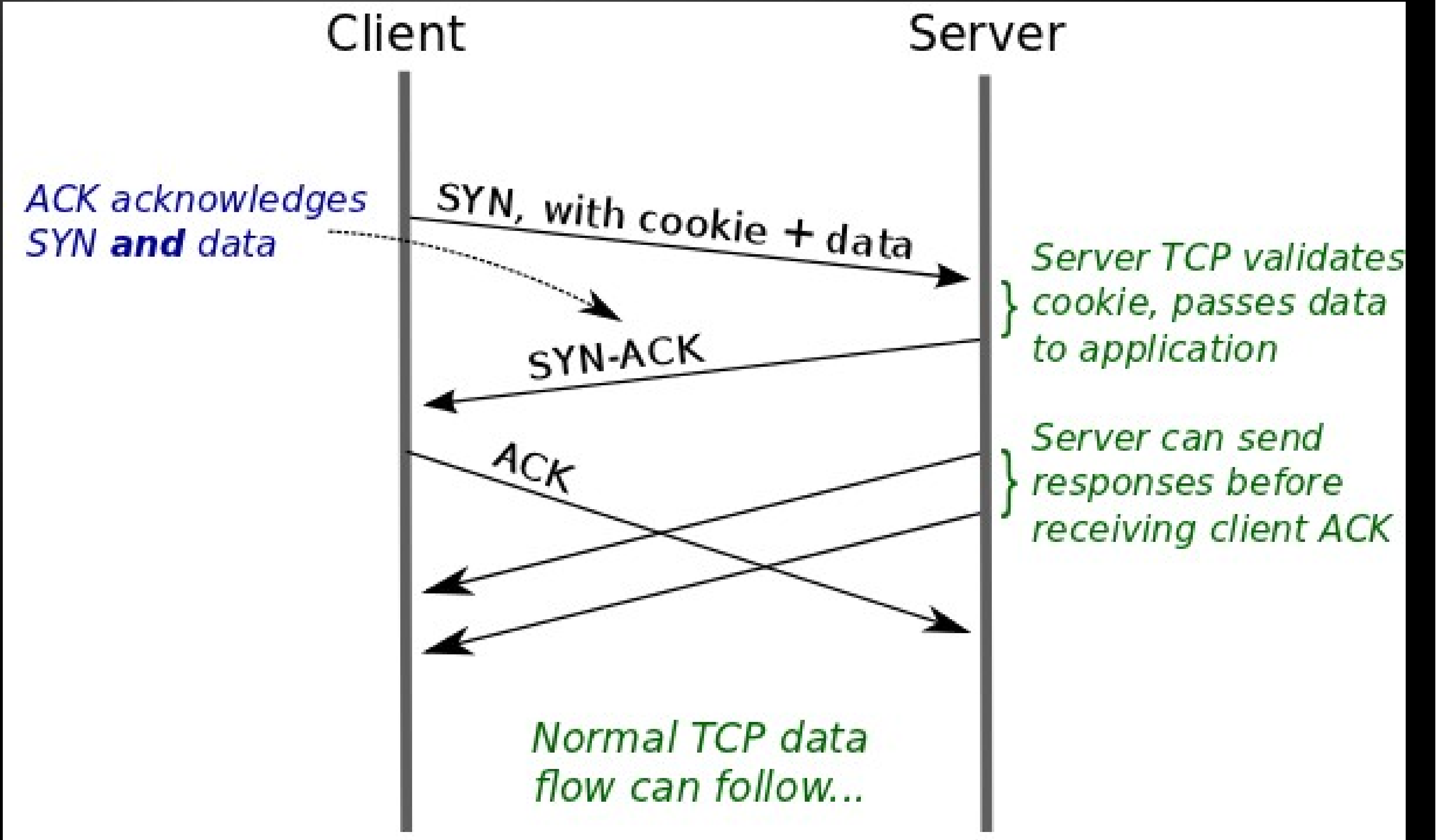
Transmission Datagram Protocol - TCP

TCP Fast open


Client
Server
SYN, with cookie request
Server TCP generates cookie, based on client IP
SYN-ACK, with cookie
Client TCP caches cookie for later use
ACK (completes 3WHS)
Normal TCP data flow can follow...

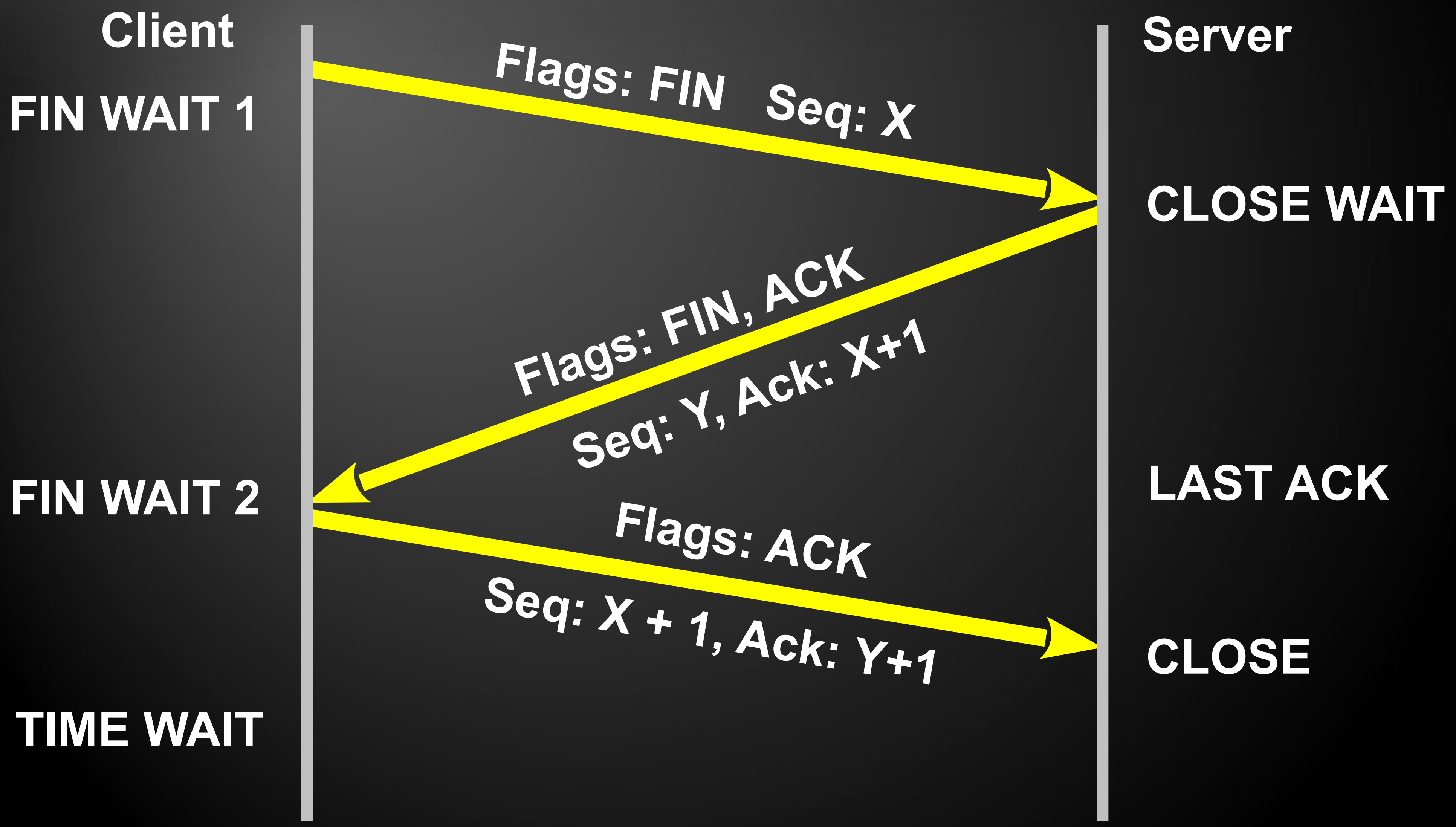
Transmission Datagram Protocol - TCP

TCP Fast open



Transmission Datagram Protocol - TCP

Connection Close

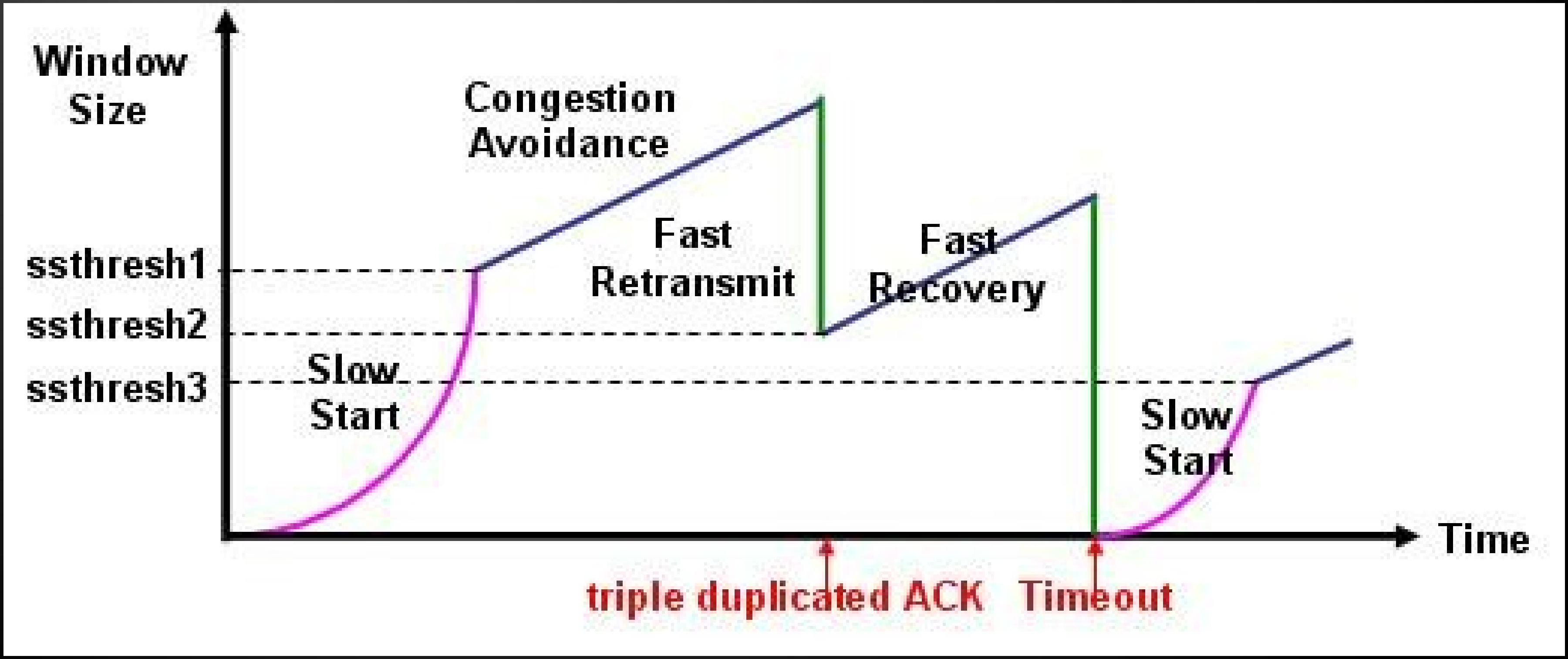


TCP Congestion

http://en.wikipedia.org/wiki/TCP_congestion_avoidance_algorithm

TCP Congestion

- Slow start
- Congestion avoidance
- Fast retransmit
- Fast Recovery



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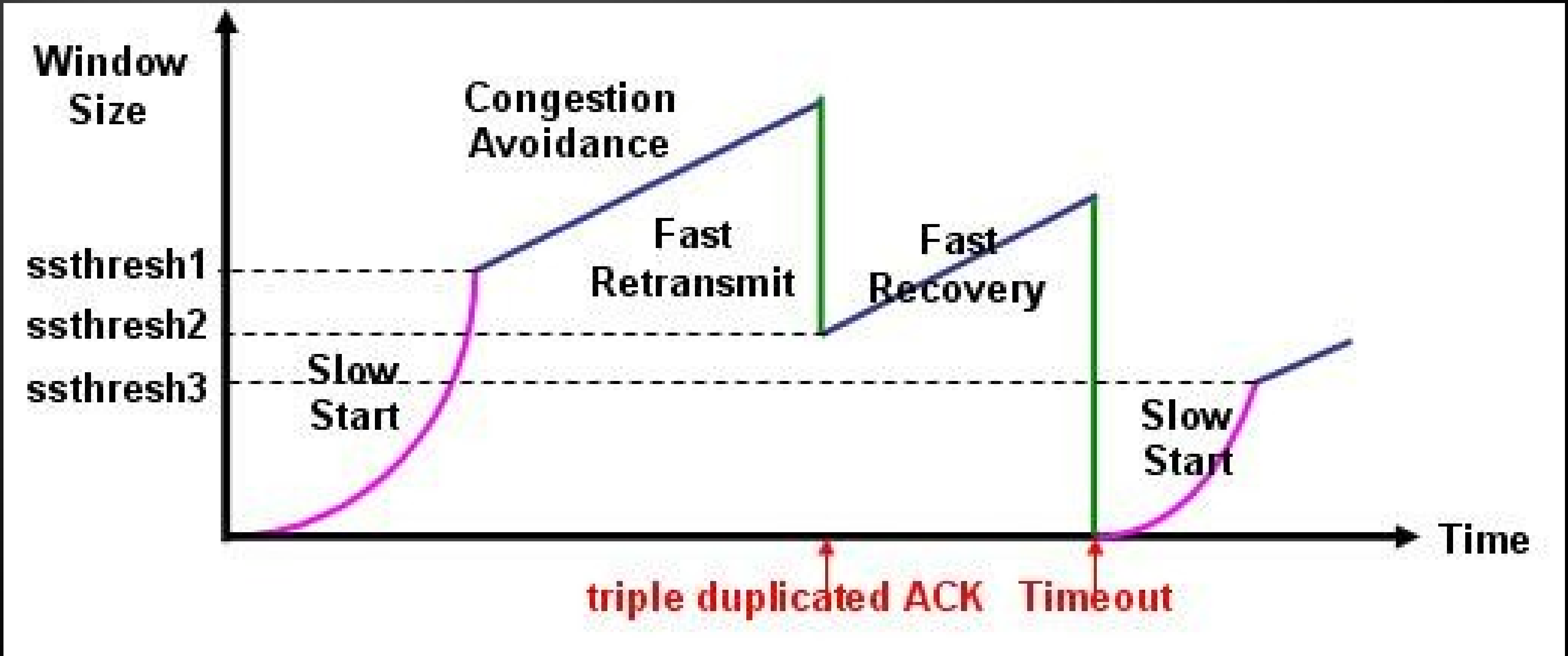
TCP Congestion – Slow start

- The initial window size is initialized to one MSS
- Each time a packet is ACKed the congestion window i increased
- When the ssthresh is reached, the next phase starts



http://en.wikipedia.org/wiki/Slow-start

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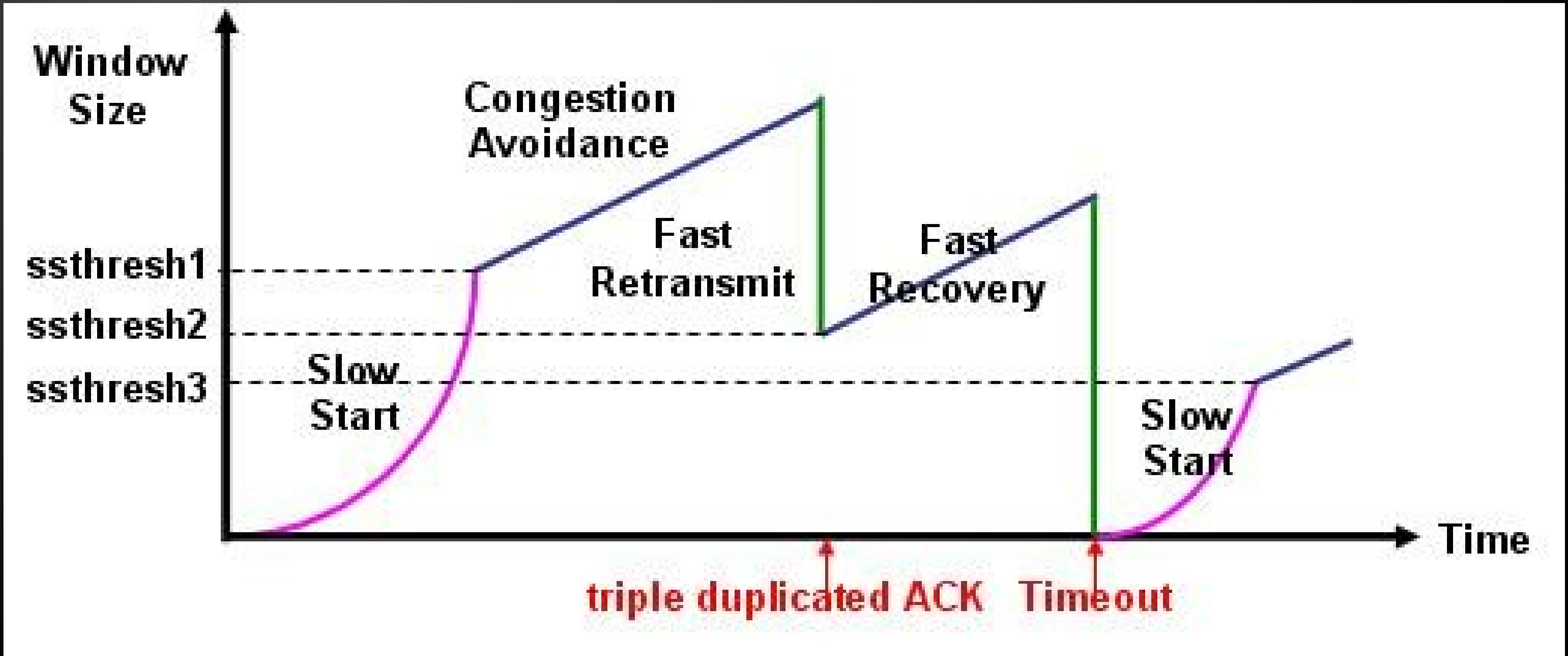
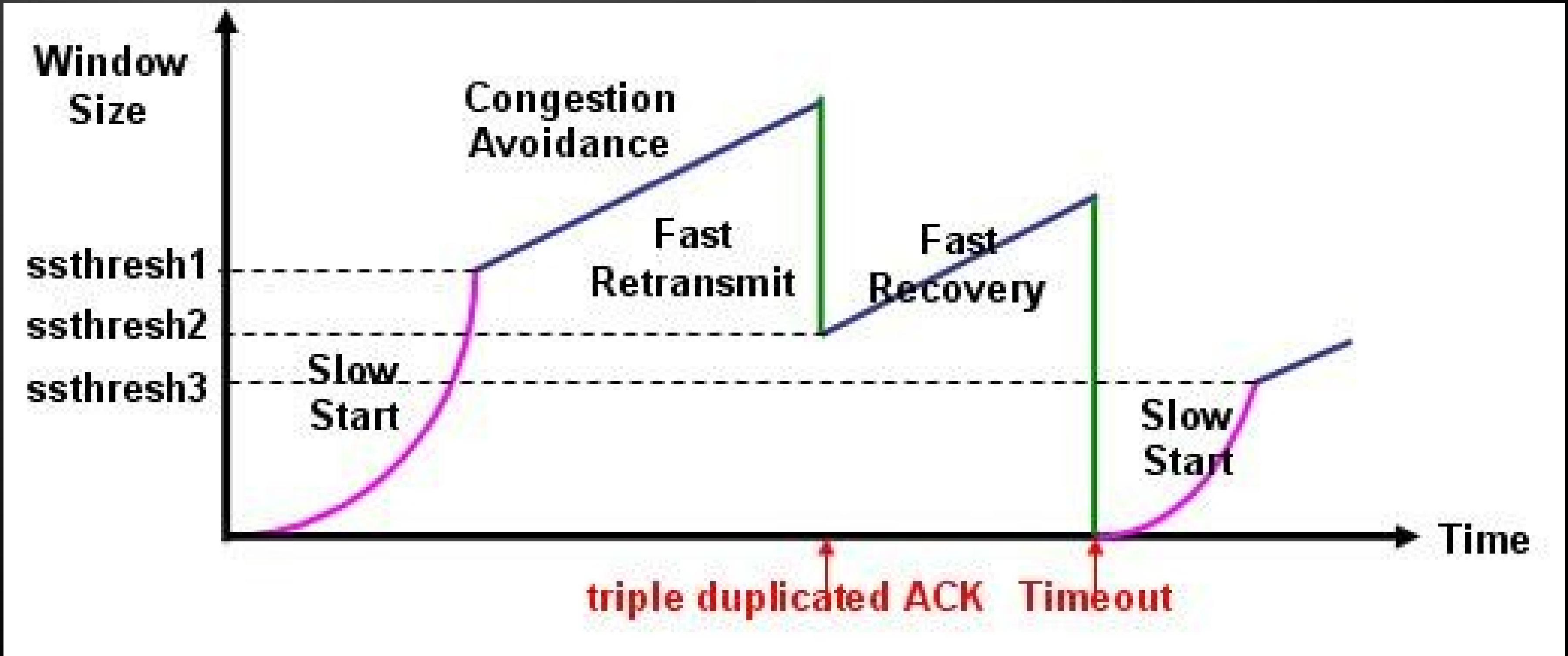
TCP Congestion – Congestion avoidance

- In this phase window size is increased linearly until timeout occurs or duplicate ACK is received



TCP Congestion – Fast retransmit

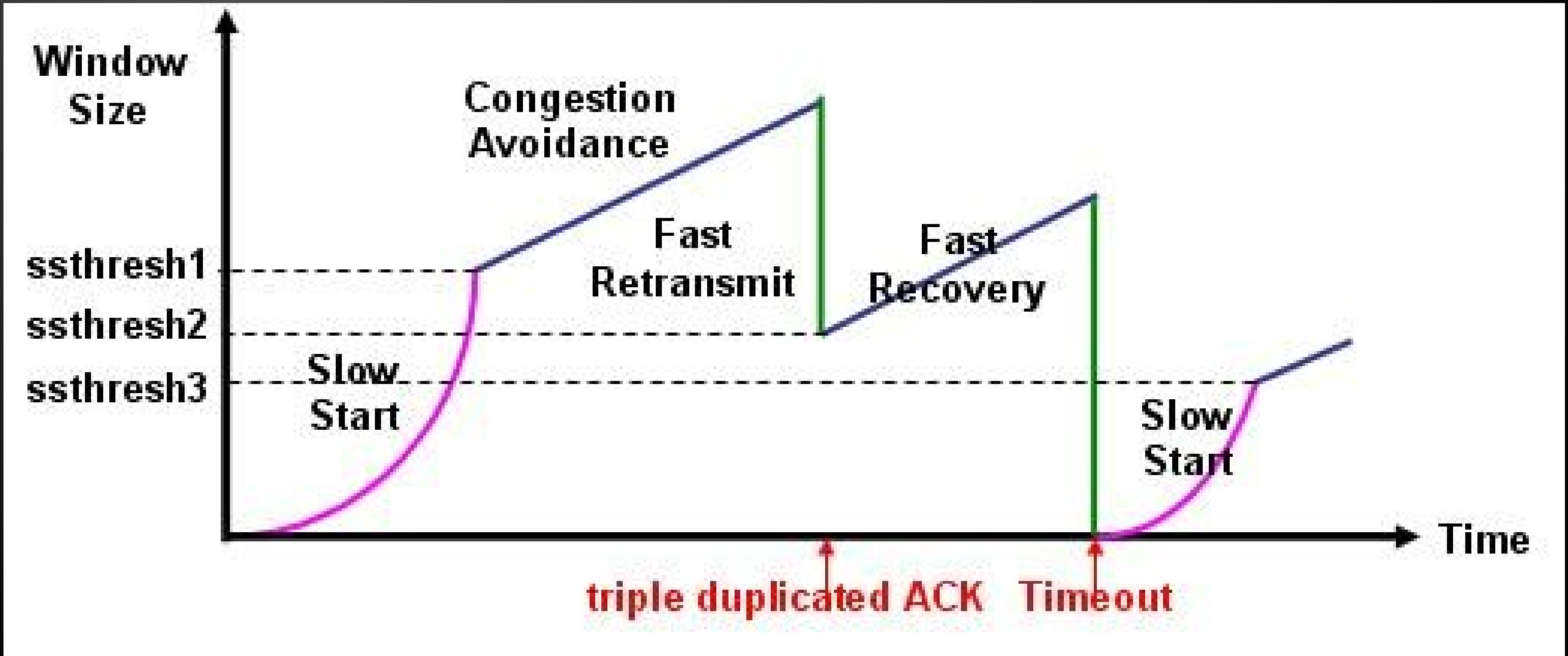
- If more then 3 ACKs are received for the same segmen the sender has to send that particular segment even be its timer has expired



http://en.wikipedia.org/wiki/Fast_retransmit

TCP Congestion – Fast Recovery

- In this phase window size is decreased to ssthresh rat then the smaller initial value and increase its size line



http://histrory.visualland.net/tcp_fast_recovery.html

TCP Congestion Avoidance - Problems

- Slow-start assumes that unacknowledged segments a due to network congestion, which is usually NOT the c in wireless networks, where dropped packets are mair because of poor data link quality.

- The slow-start protocol performs badly for short-livec connections, because it actually slows down the transmission of data.

- It is possible to trick the congestion avoidance algori to think that the pipe is full and slow down all connect originating from that machine.

TCP Keepalive

- The keepalive packets are packets which contain no sent at regular interval to confirm that this connectio alive

- Keepalive time is the duration between two keepaliv transmissions in idle condition. TCP keepalive period required to be configurable and by default is set to no than 2 hours.
- Keepalive interval is the duration between two succe keepalive retransmissions, if acknowledgement to the previous keepalive transmission is not received. Usua around 75 seconds.
- Keepalive retry is the number of retransmissions to b sent out before declaring that remote end is not availa

Datagram Congestion Control Protocol

- Basically DCCP is UDP with congestion control mechai

It features

- Unreliable flows of datagrams
- Reliable handshakes for connection setup and teardow
- Negotiation of a suitable congestion control mechanisn
- Acknowledgment mechanisms communicating packet l
- Path Maximum Transmission Unit (PMTU) discovery

- RFC4340

DCCP header (x = 1)

```
0                   1                   2                   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          |           Dest Port           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Data Offset  | CCVal | CsCov |           Checksum            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     |       |X|               |                               .
| Res | Type  |=|   Reserved    |  Sequence Number (high bits)  .
|     |       |1|               |                               .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
.                  Sequence Number (low bits)                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

If X is 1 the Sequence Number field is 48 bits long

DCCP header (x = 0)

```
 0                   1                   2                   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          |           Dest Port           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Data Offset  | CCVal | CsCov |           Checksum            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     |       |X|                                               |
| Res | Type  |=|          Sequence Number (low bits)           |
|     |       |0|                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

If X is 0 the Sequence Number field is 24 bits long

Data Offset - the offset from the start of the packet's DCCP header to t
start of its application data area

CCVal - Defines the congestion control algorithm used

- CCVal = 2 - TCP like congestion avoidance
- CCVal = 3 - TCP friendly congestion avoidance

CsCov - Checksum Coverage determines the parts of the packet that are covered by the Checksum field.

Checksum – DCCP header checksum

Type – DCCP packet type

X - Extended Sequence Numbers (may be 0 or 1)

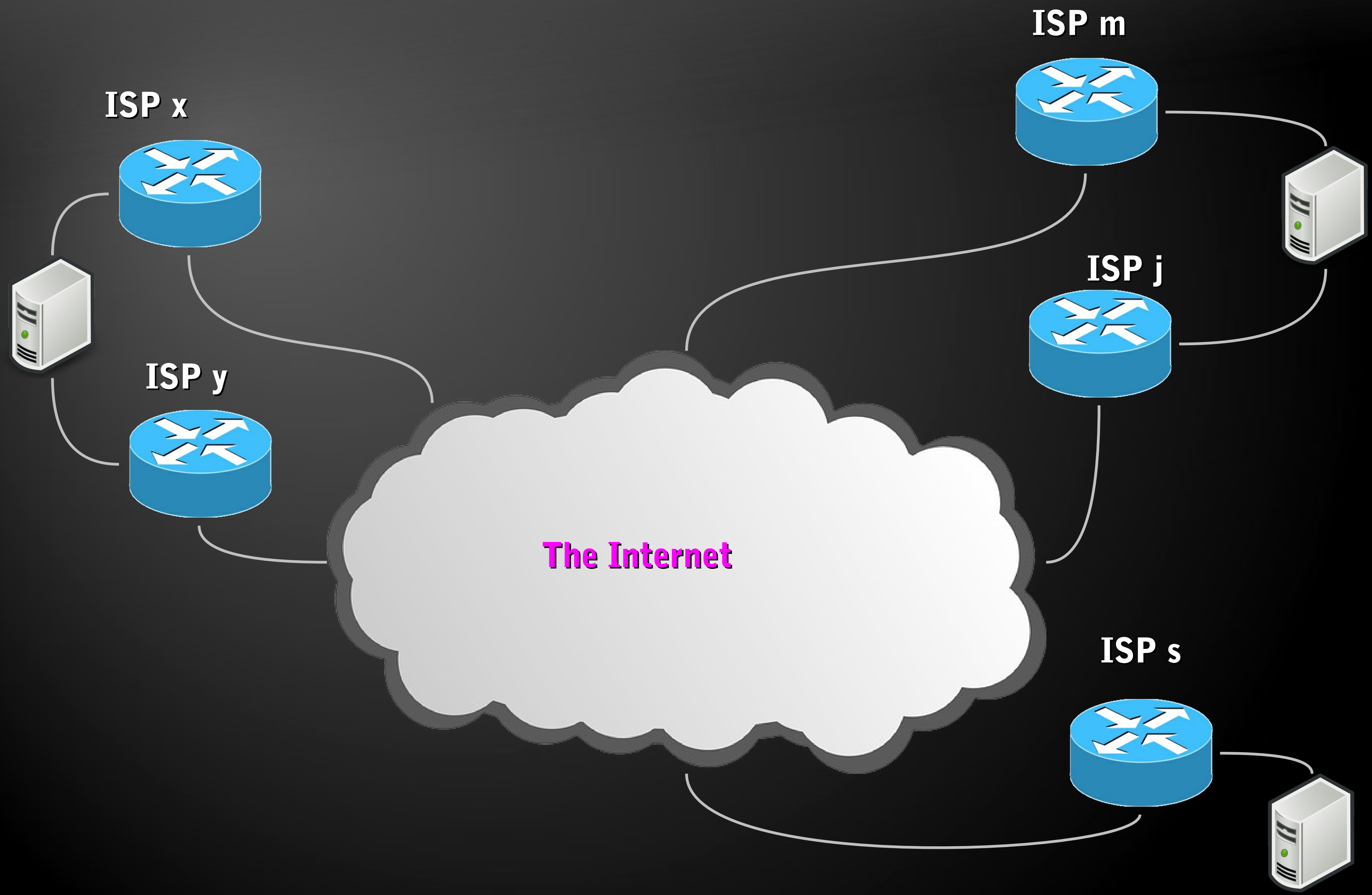
DCCP header

```
All currently defined packet types except DCCP-Request and DCCP-Data
carry an Acknowledgment Number Subheader

When X=1, its format is:

 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |           Reserved            |    Acknowledgment Number      .
 |                               |          (high bits)          .
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 .                Acknowledgment Number (low bits)               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

When X=0, only the low 24 bits of the Acknowledgment Number are
transmitted, giving the Acknowledgment Number Subheader this format:

 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |   Reserved    |        Acknowledgment Number (low bits)       |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

DCCP packet types

Type	Meaning
0	DCCP-Request
1	DCCP-Response
2	DCCP-Data
3	DCCP-Ack
4	DCCP-DataAck
5	DCCP-CloseReq
6	DCCP-Close
7	DCCP-Reset
8	DCCP-Sync
9	DCCP-SyncAck
10-15	Reserved

Multihoming



Stream Control Transmission Protocol

- Multihoming support in which one or both endpoints of a connection can consist of more than one IP address, enabling transparent fail-over between redundant network paths.
- Delivery of chunks within independent streams eliminate unnecessary head-of-line blocking
- Path selection and monitoring
- Validation and acknowledgment mechanisms protect against flooding attacks and provide notification of duplicated or missing data chunks.
- Improved error detection suitable for Ethernet jumbo frames.

Stream Control Transmission Protocol

```
0                   1                   2                   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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Common Header                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Chunk #1                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           ...                                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Chunk #n                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

RFC4960

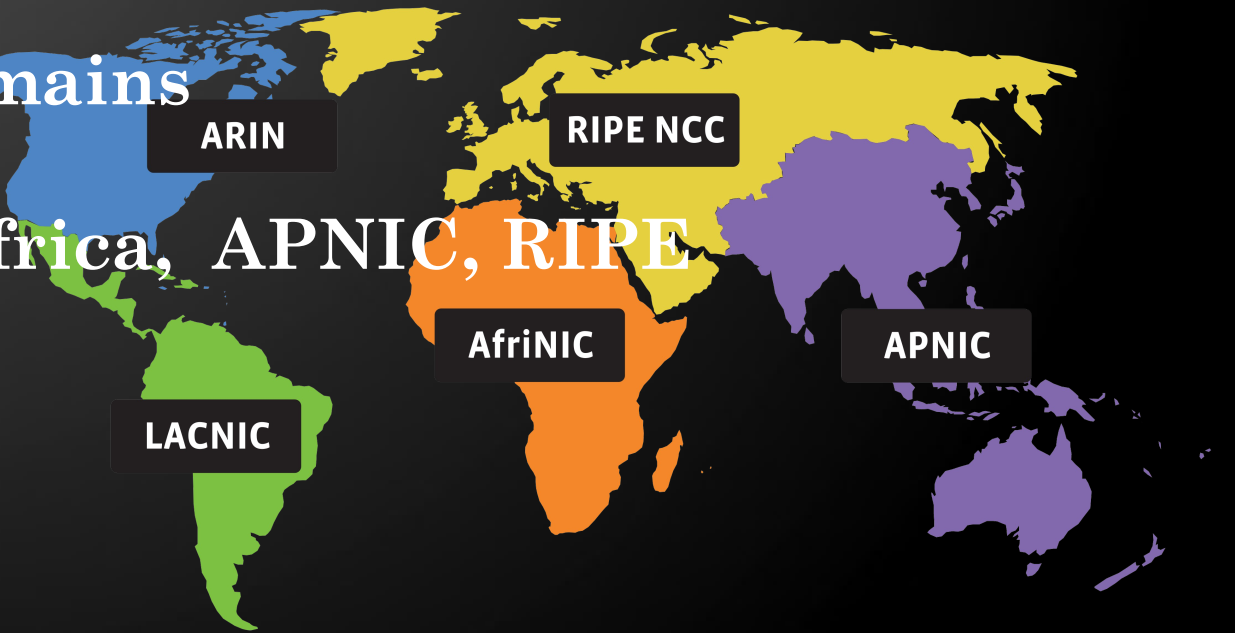
Stream Control Transmission Protocol

```
                          Common Header
0                   1                   2                   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 Number        |     Destination Port Number   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Verification Tag                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Checksum                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

RFC4960

IP & Domain allocation

- IANA – www.iana.org
  - Number resources
    - IP Addresses
    - Autonomous System (AS)
    - Protocol number assignments
  - Domain assignments
    - Root zone management
    - gTLD database
    - .int and .arpa domains
- IP registrars
  - ARIN, LACNIC, Africa, APNIC, RIPE



IP & Domain allocation

- Regional Internet Registrar(RIR)
- Local Internet Registrar(LIR)
- There are two types of IP addresses that can be reque
  - Provider dependent
    - These you get from your ISP
  - Provider independent
    - You get them from the local LIR or the regional RIR
    - These allocations can not be smaller then /24 netwo
- Autonomous System (AS)
  - Used for the BGP routing protocol
  - Aggregated IP route announcements are made from to them
  - The corner stone of the Internet routing
  - Look at http://www.youtube.com/watch?v=oK-lgjJhC

Domain Name System - DNS

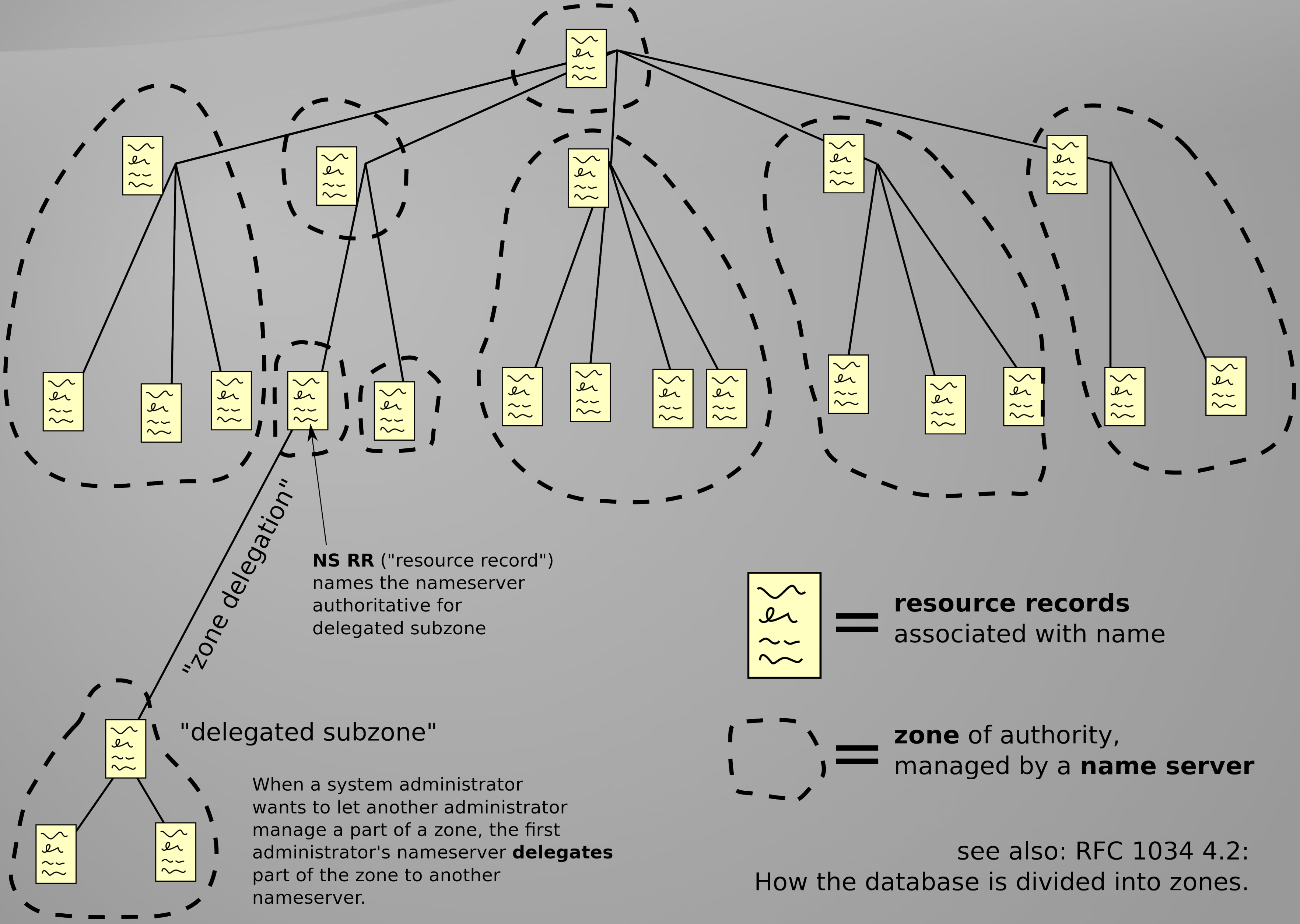
Everything was 'hosts':

```
127.0.0.1              localhost
192.168.0.174     store1
192.168.0.238     store2
192.168.0.244     store3
192.168.155.2     operations
192.168.155.149 zimbra0.siteground.com
193.107.36.190         sapport.bg www.sapport.bg
8.8.8.8                ns.google.com
89.25.120.31           google.com
89.25.120.24           www.google.com
```

Linux: /etc/hosts

Windows: C:\Windows\System32\drivers\etc\hosts

Domain Name Space



NS RR ("resource record") names the nameserver authoritative for delegated subzone

"delegated subzone"

When a system administrator wants to let another administrator manage a part of a zone, the first administrator's nameserver **delegates** part of the zone to another nameserver.

= **resource records** associated with name

= **zone** of authority, managed by a **name server**

see also: RFC 1034 4.2:
How the database is divided into zones.

DNS

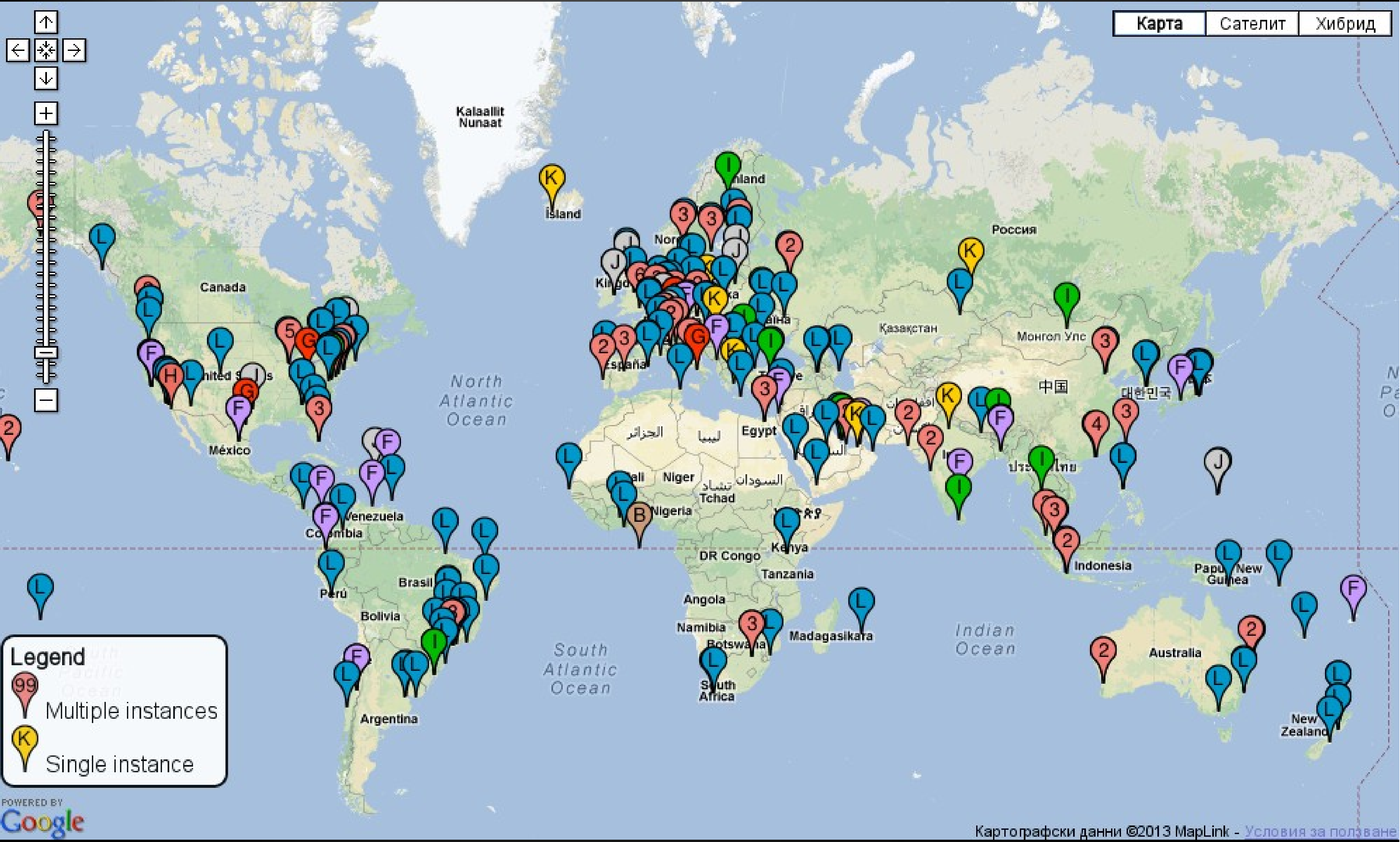
- Internet Corporation For Assigned Names and Numbe
  - IANA is now part of it
  - Handles ccTLDs
  - Handles gTLDs
  - Handles the Root zone

- Country level domains
  - .bg, .co.za, .co.uk, .edu.us

- Top-level domains
  - .com, .net, .org, .edu, .gov, .mil
  - .biz, .name, .info

- Instances of J and L root servers are hosted in Sofia

DNS

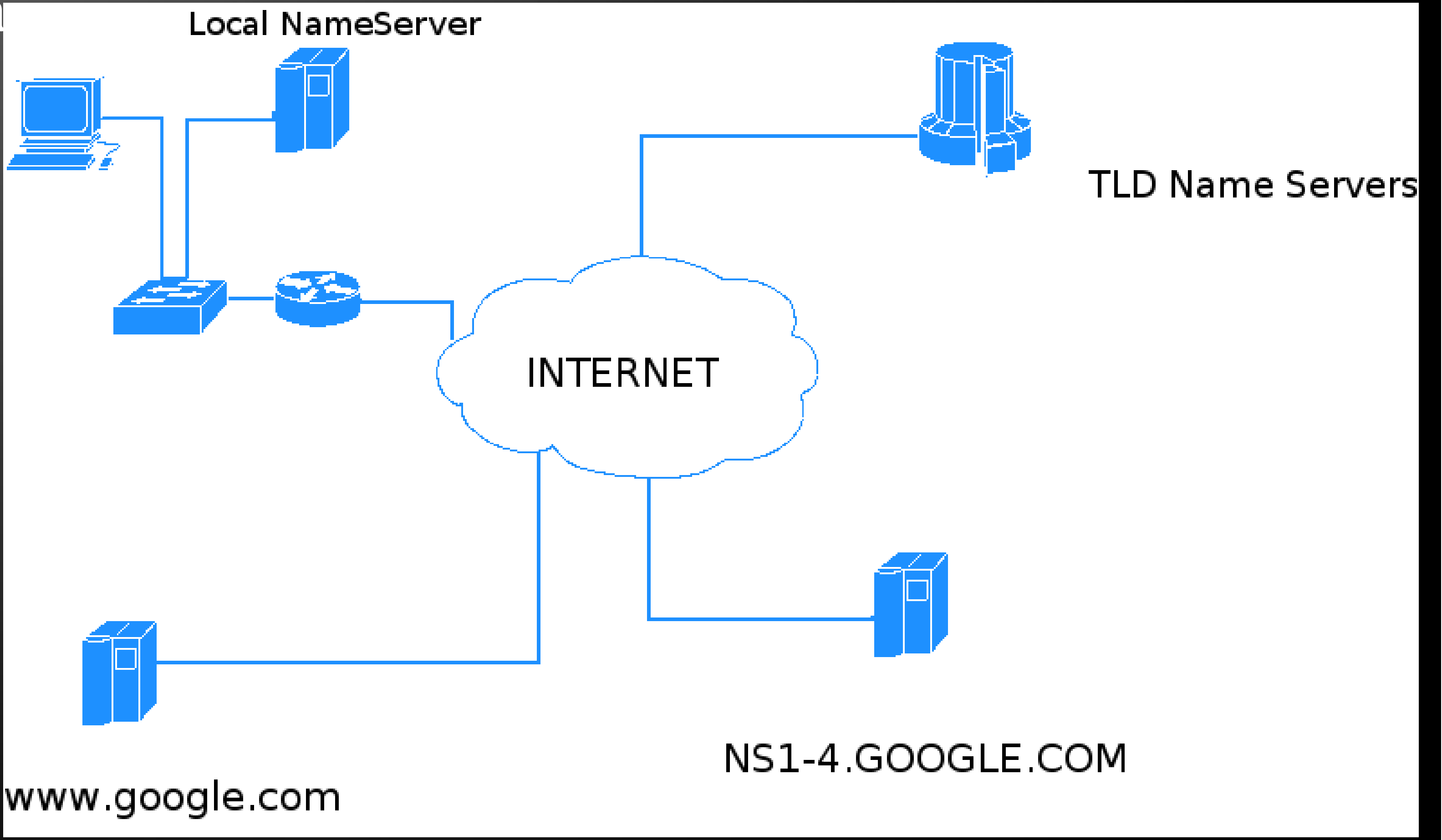

Карта
Сателит
Хибрид
Kalaallit Nunaat
Ísland
Россия
Canada
Қазақстан
Монгол Улс
中国
대한민국
España
North Atlantic Ocean
México
Egypt
Niger
Tchad
Nigeria
Venezuela
Colombia
Perú
Brasil
Bolivia
Argentina
DR Congo
Kenya
Tanzania
Angola
Namibia
Botswana
Madagasikara
South Africa
South Atlantic Ocean
Indian Ocean
Indonesia
Papua New Guinea
Australia
New Zealand
Legend
Multiple instances
Single instance
POWERED BY Google
Картографски данни ©2013 MapLink - Условия за ползване

DNS

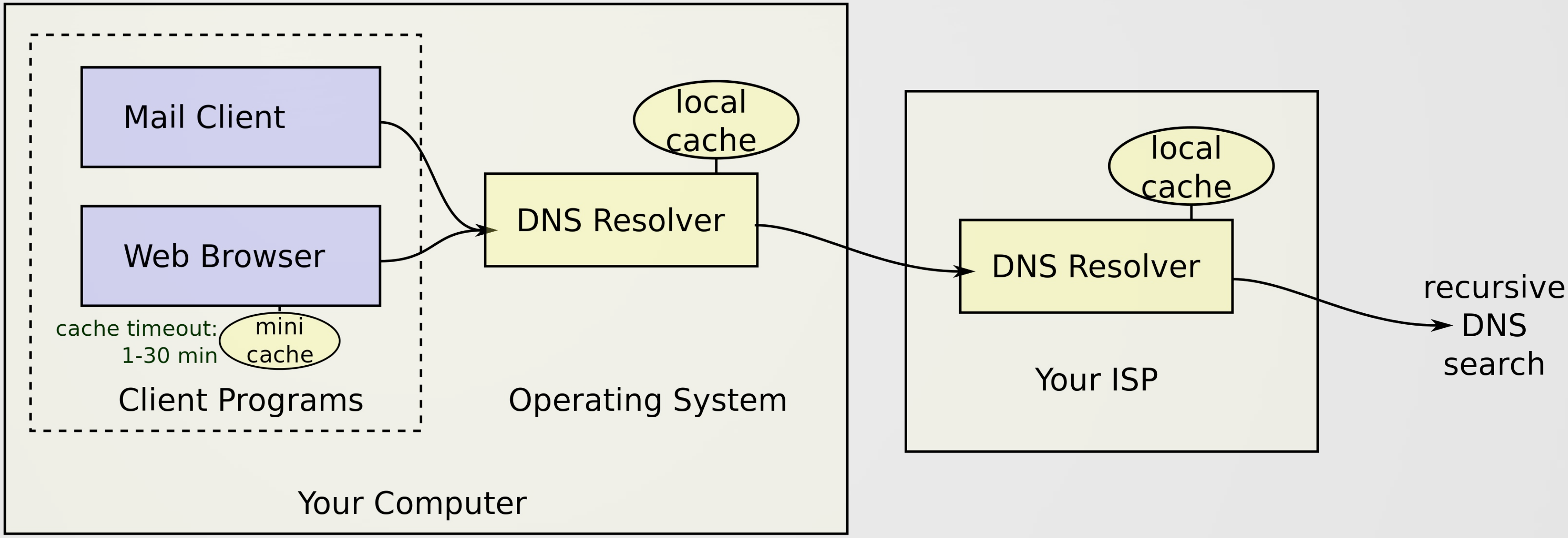
- Internet Corporation For Assigned Names and Numbe
  - IANA is now part of it
  - Handles ccTLDs
  - Handles gTLDs
  - Handles the Root zone
- Internationalized domain name (IDN)
  - Domain names are encoded using Punycode
  - .ru = .рф
  - We are expecting soon .bg = .бг
- Country level domains
  - .bg, .co.za, .co.uk, .edu.us
- Top-level domains
  - .com, .net, .org, .edu, .gov, .mil
  - .biz, .name, .info

DNS

- Name servers
  - Authoritative only
  - Recursive
  - Authoritative + recursive
- .in-addr.arpa
- .ip6.arpa



DNS - Resolving

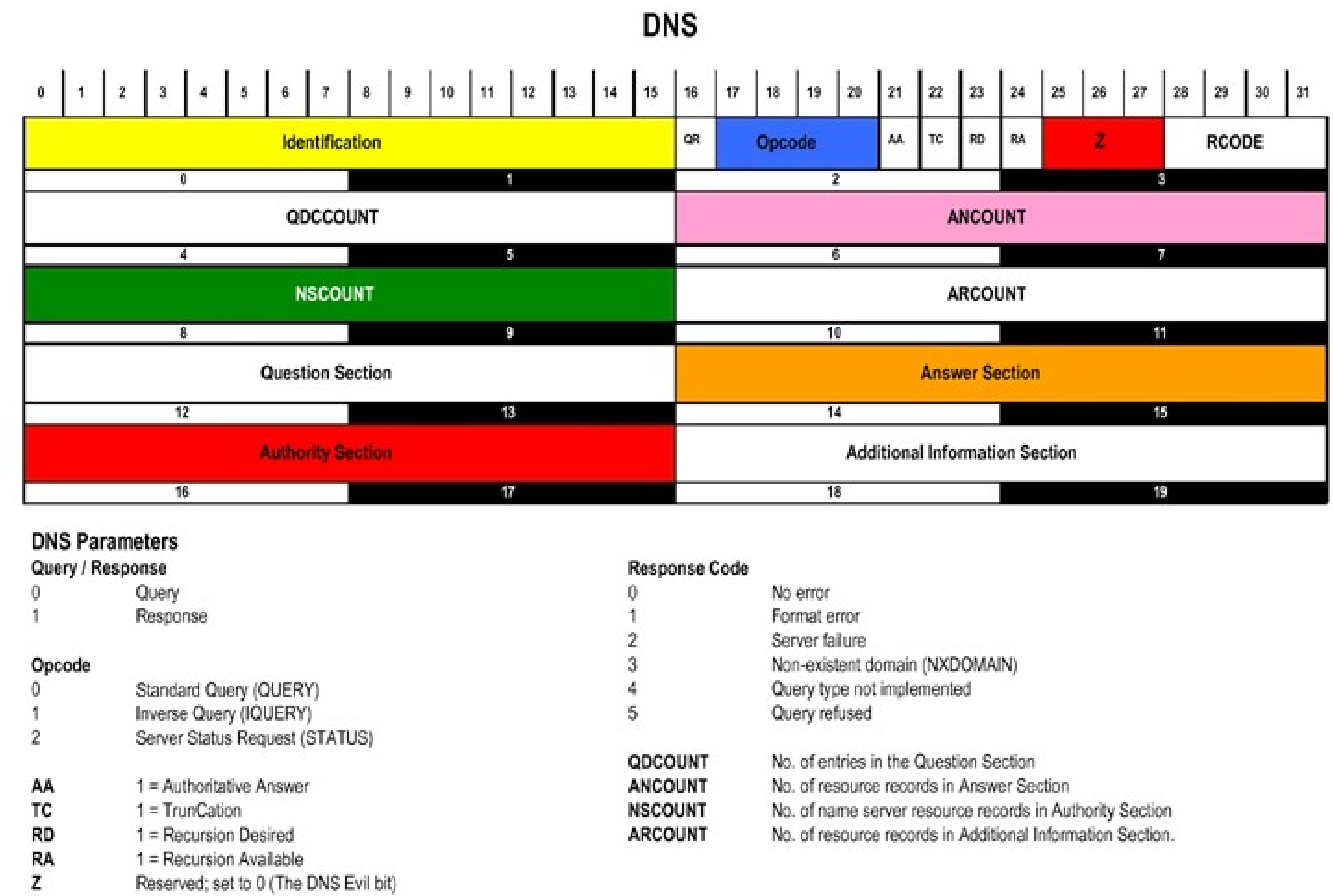


Default service port TCP/UDP: 53

DNS - Resolving

- Forward resolving
  - Host/FQDN to IP
- Reverse resolving
  - IP to Host
- Reverse resolver delegation
  - RIR -> LIR -> Local ISP -> YOU

DNS



DNS

0–15	16	17–20	21	22	23	24	25–27	28–31
Identification	QR	Opcode	AA	TC	RD	RA	Z	RCODE
0 / 1		2				3		
QDCCOUNT	ANCOUNT							
4 / 5	6 / 7							
NSCOUNT	ARCOUNT							
8 / 9	10 / 11							
Question Section	Answer Section							
12 / 13	14 / 15							
Authority Section	Additional Information Section							
16 / 17	18 / 19							

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 (The DNS Evil bit)

Response Code

0	No error
1	Format error
2	Server failure
3	Non-existent domain (NXDOMAIN)
4	Query type not implemented
5	Query refused

QDCOUNT	No. of entries in the 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.

DNS Resource records

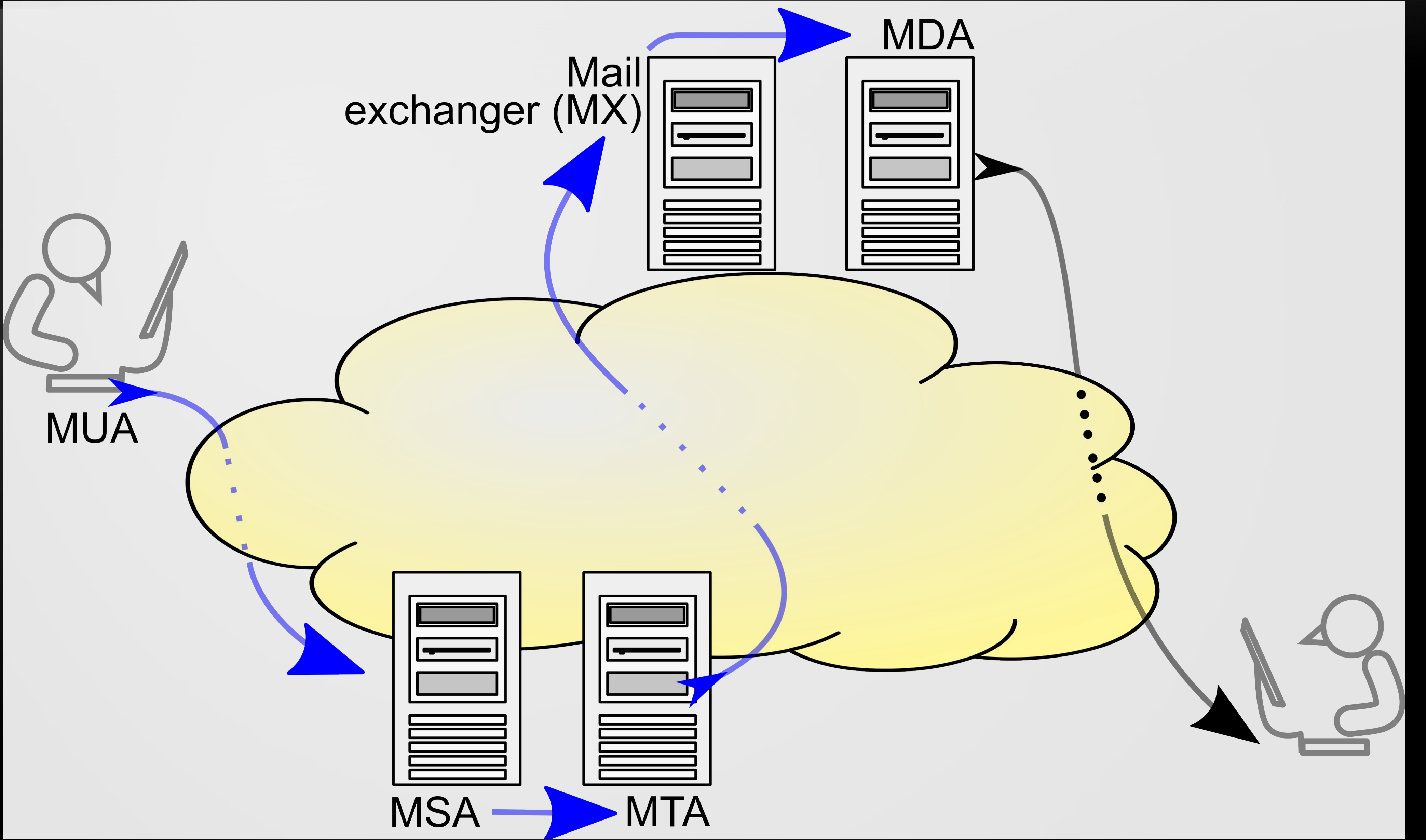
TYPE	value and meaning	
A	1	a host address
NS	2	an authoritative name server
CNAME	5	the canonical name for an alias
SOA	6	start of a zone of authority
WKS	11	a well known service description
PTR	12	a domain name pointer
HINFO	13	host information
MINFO	14	mailbox or mail list information
MX	15	mail exchange
TXT	16	text strings
AXFR	252	A request for a transfer of an entire zone

RFC1035

DNS Resource records

```
kar-do.cc. 86400 IN SOA     ns1.ex1.com.
  mm.yuhu.biz.   (
     2013013106  ;Serial Number
     86400       ;refresh
     7200        ;retry
     3600000     ;expire
     86400       ;minimum
)
kar-do.cc.   IN      NS      ns1.ex1.com.
kar-do.cc.   IN      NS      ns2.ex1.com.
kar-do.cc.   IN      A       134.154.23.12
localhost    IN      A       127.0.0.1
kar-do.cc.   IN      MX      0  mail.kar-do.cc.
mail         IN      CNAME   mail.yuhu.biz.
www          IN      A       134.154.23.12
www          IN      A       134.142.65.81
kar-do.cc.   IN      TXT
         "v=spf1 +a +mx +ip4:134.154.23.12 ?all"
```

Send Mail Transport Protocol - SMTP



RFC5321

Send Mail Transport Protocol - SMTP

```
S: 220 smtp.example.com ESMTP Postfix
C: HELO relay.example.org
S: 250 Hello relay.example.org, I am glad to meet you
C: MAIL FROM:<bob@example.org>
S: 250 Ok
C: RCPT TO:<alice@example.com>
S: 250 Ok
C: RCPT TO:<theboss@example.com>
S: 250 Ok
C: DATA
S: 354 End data with <CR><LF>.<CR><LF>
C: From: "Bob Example" <bob@example.org>
C: To: "Alice Example" <alice@example.com>
C: Cc: theboss@example.com
C: Date: Tue, 15 January 2008 16:02:43 -0500
C: Subject: Test message
C:
C: Hello Alice.
C: This is a test message with 5 header fields and 4 lines in the message body.
C: Your friend,
C: Bob
C: .
S: 250 Ok: queued as 12345
C: QUIT
S: 221 Bye
```

HTTP

- In this phase window size is increased linearly until timeout occurs or duplicate ACK is received

Questions?

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