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Trinity College Dublin
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The University of Dublin

CSU33031 Computer Networks

IP Address Rerun

Stefan Weber

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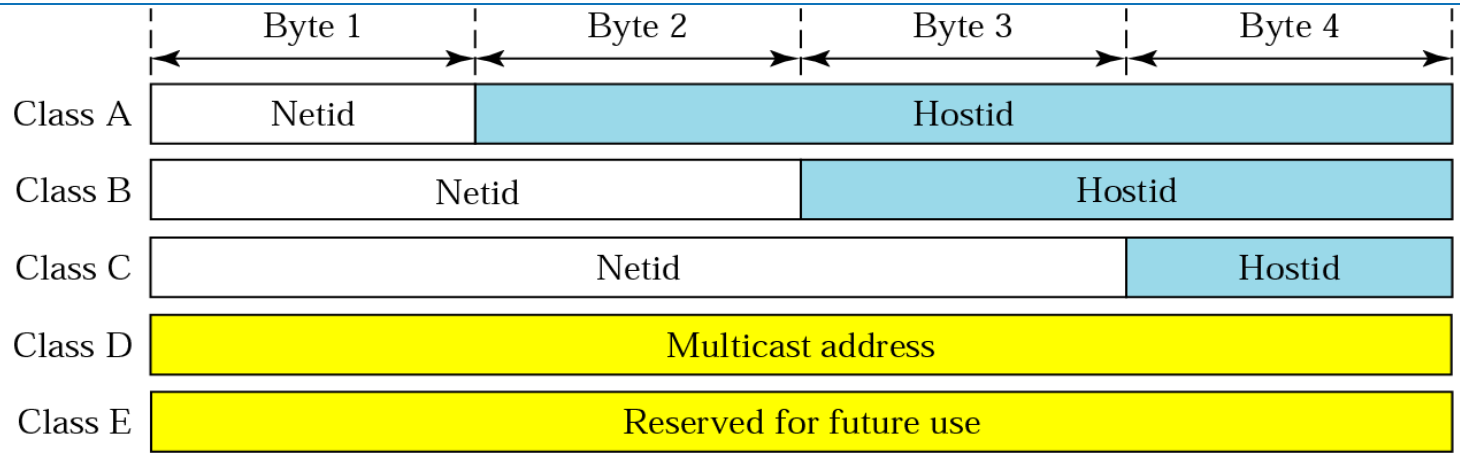
Office: Lloyd 1.41

Classful Addresses

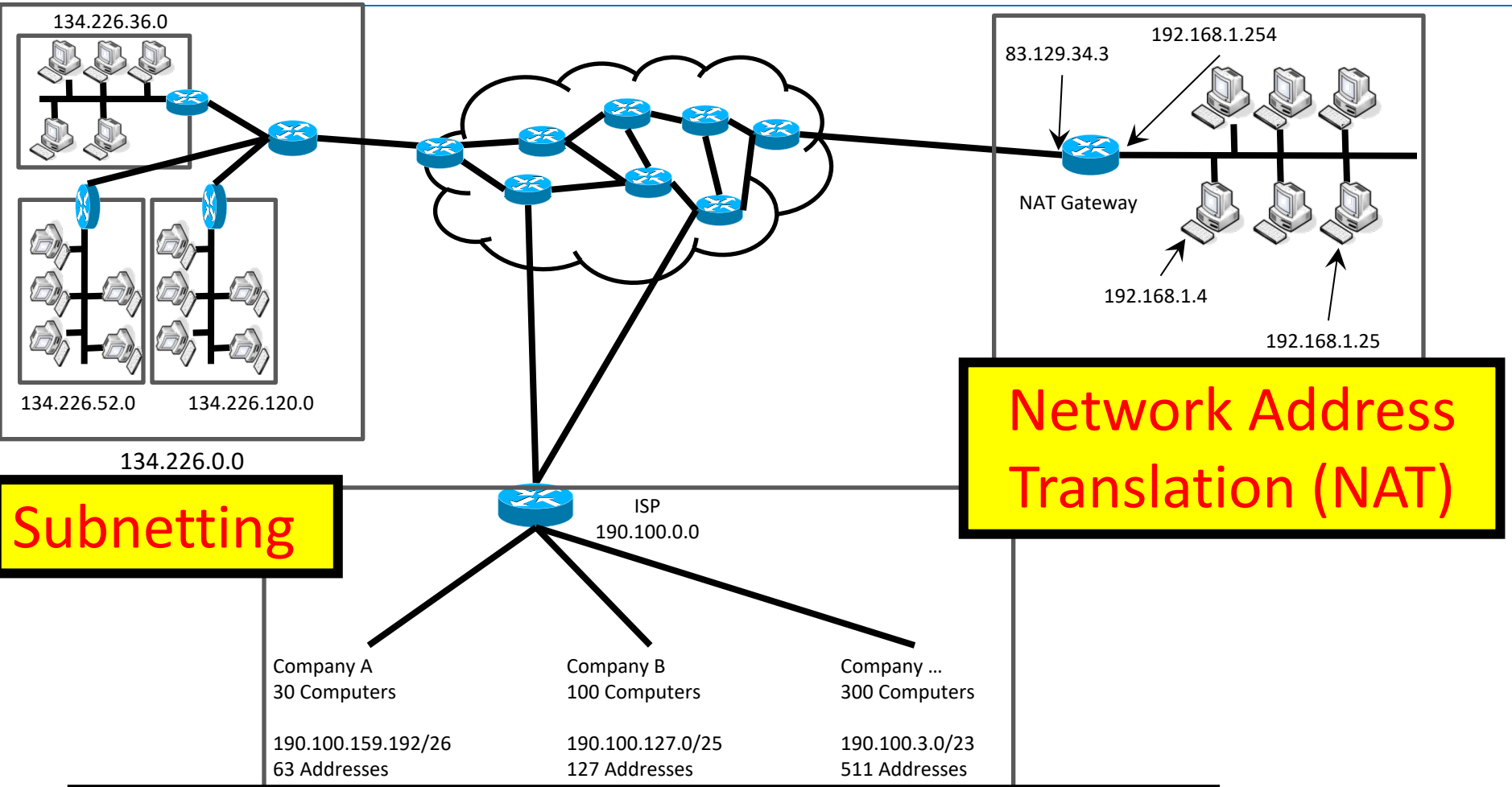


- Class A (international organisations)
  - 126 networks with 16,277,214 hosts each
- Class B (large companies)
  - 16,384 networks with 65,354 hosts each
- Class C (smaller companies)
  - 2,097,152 networks with 254 hosts each

- Inefficient use of hierarchical address space
  - Class C with 2 hosts (2/254 = 0.78% efficient)
  - Class B with 256 hosts (256/65534 = 0.39% efficient)

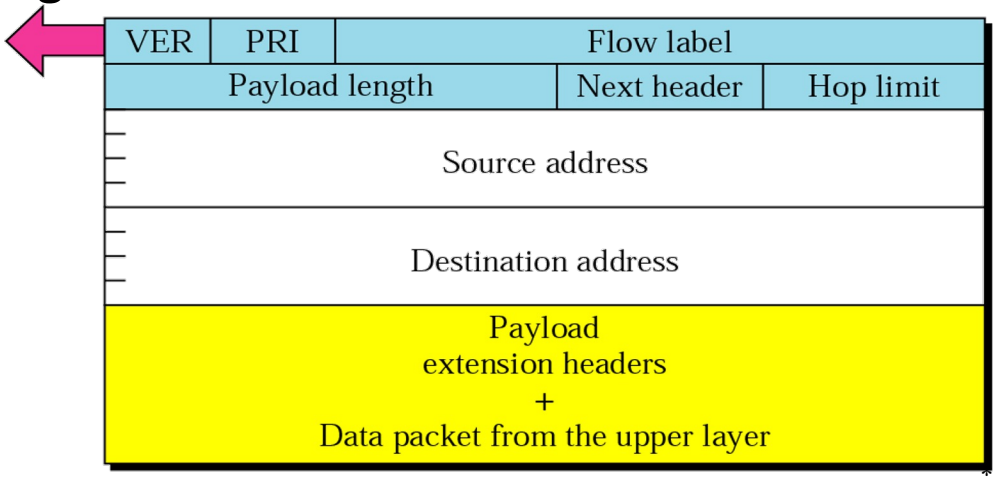
* Figure is courtesy of B. Forouzan

Developments re IP Addresses



IPv6 Header

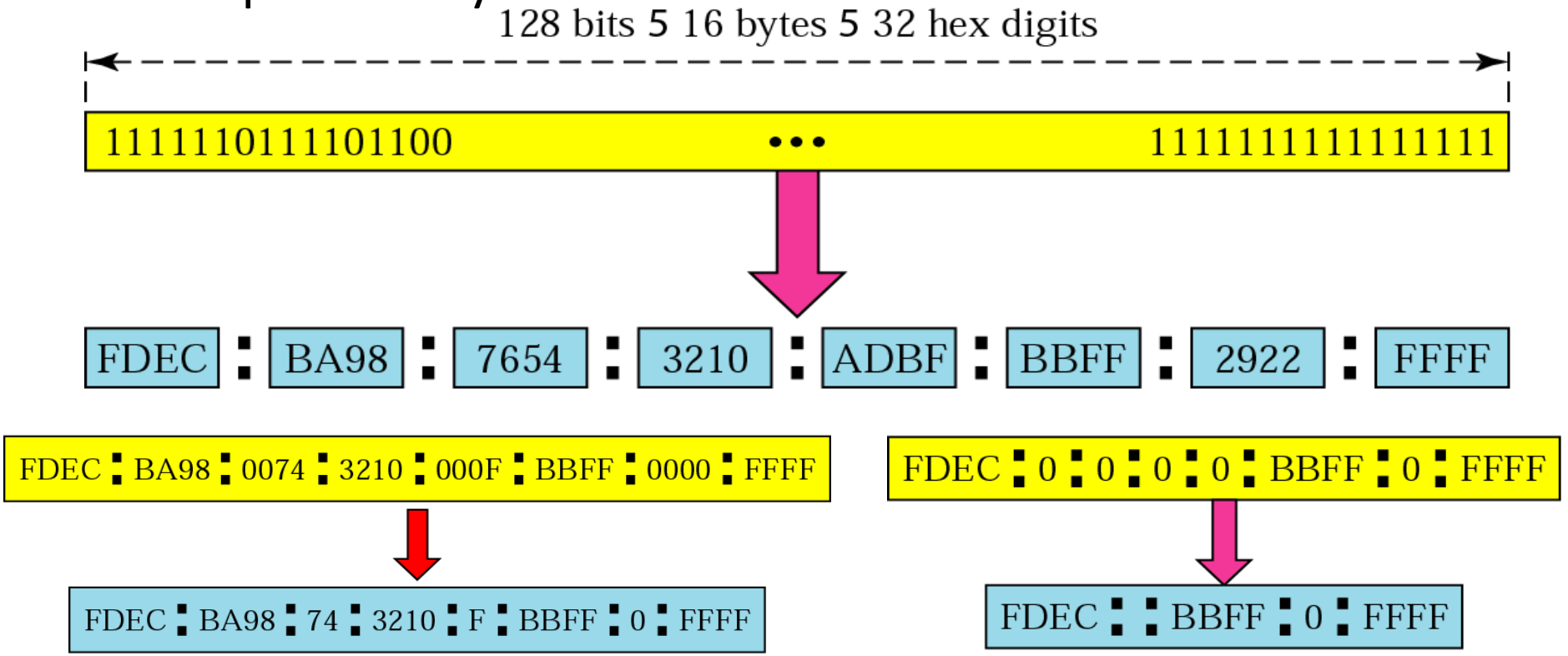
- Fixed length of all fields, header length irrelevant
- Remove Header Checksum – other layers are responsible
- No hop-by-hop fragmentation – fragment offset irrelevant
  - MTU discovery before sending or minimum MTU=1280
- Extension headers – next header type
- Basic Principle: Routers along the way should do minimal processing



* Figure is courtesy of B. Forouzan

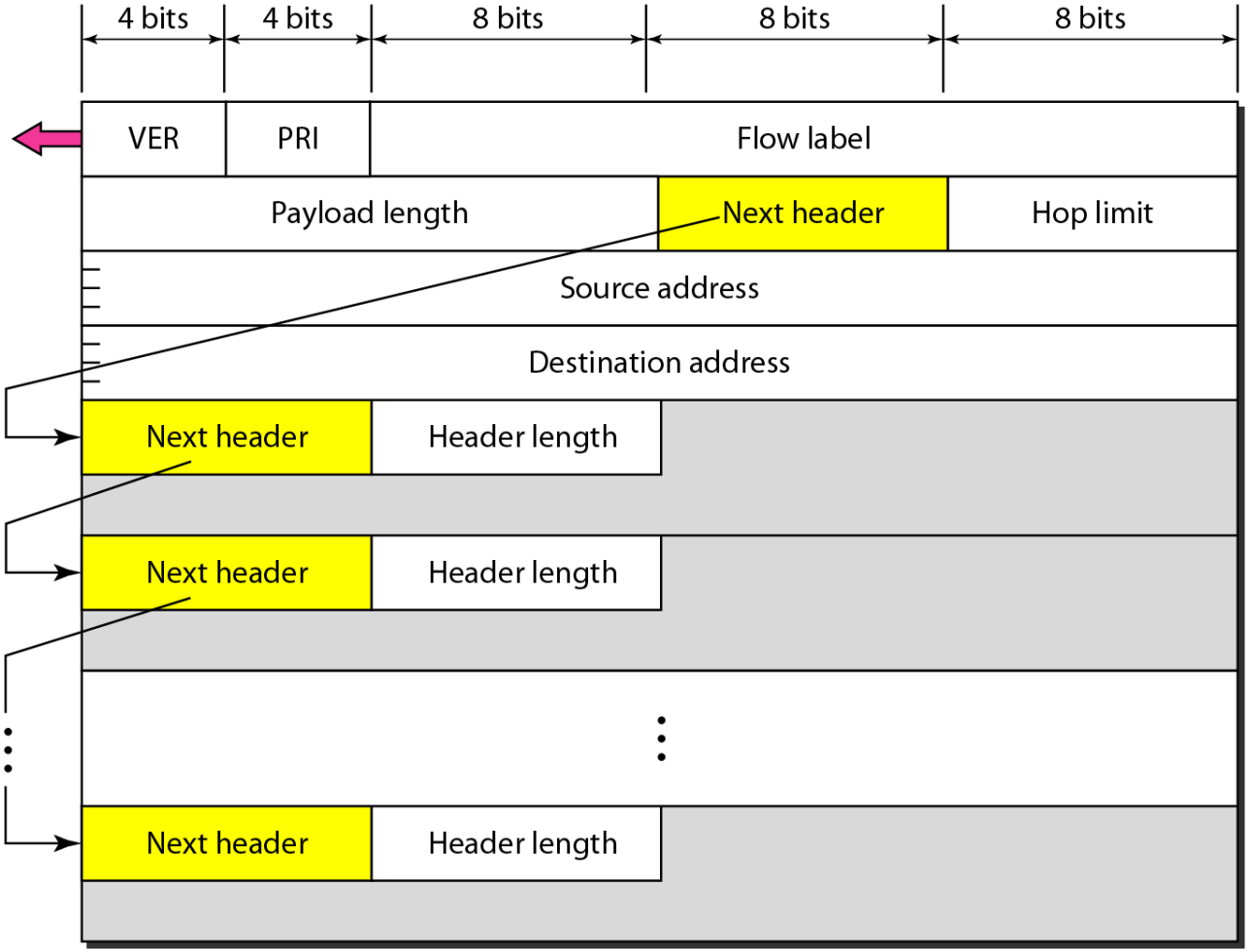
IPv6 Address

- Standard representation is set of eight 16-bit values separated by colons



* Figure is courtesy of B. Forouzan

Extension Headers



* Figure is courtesy of B. Forouzan

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CSU33031 Computer Networks

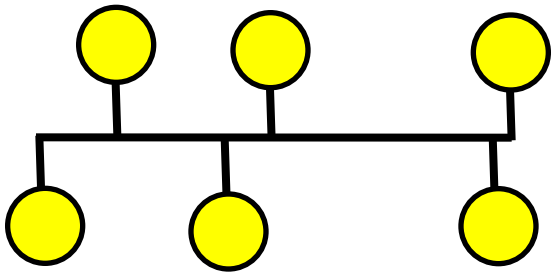
User Datagram Protocol (UDP)

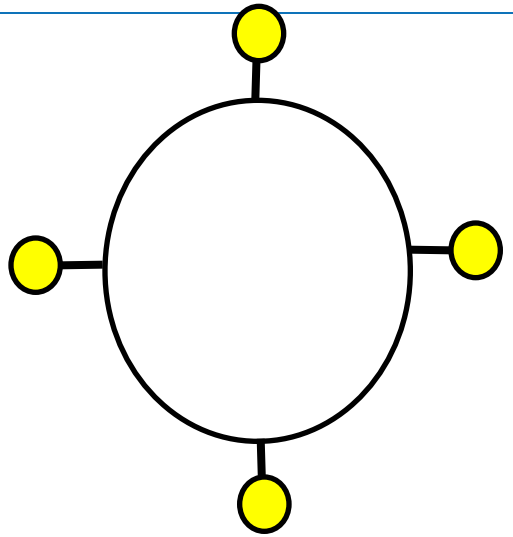
Stefan Weber

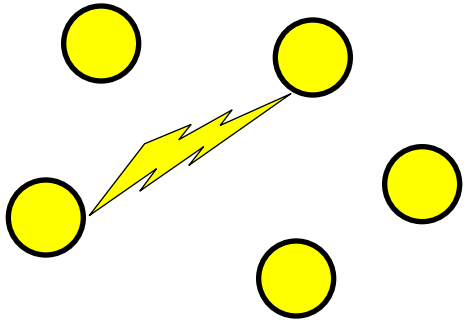
email: sweber@tcd.ie

Office: Lloyd 1.41

Naming at the Link Layer





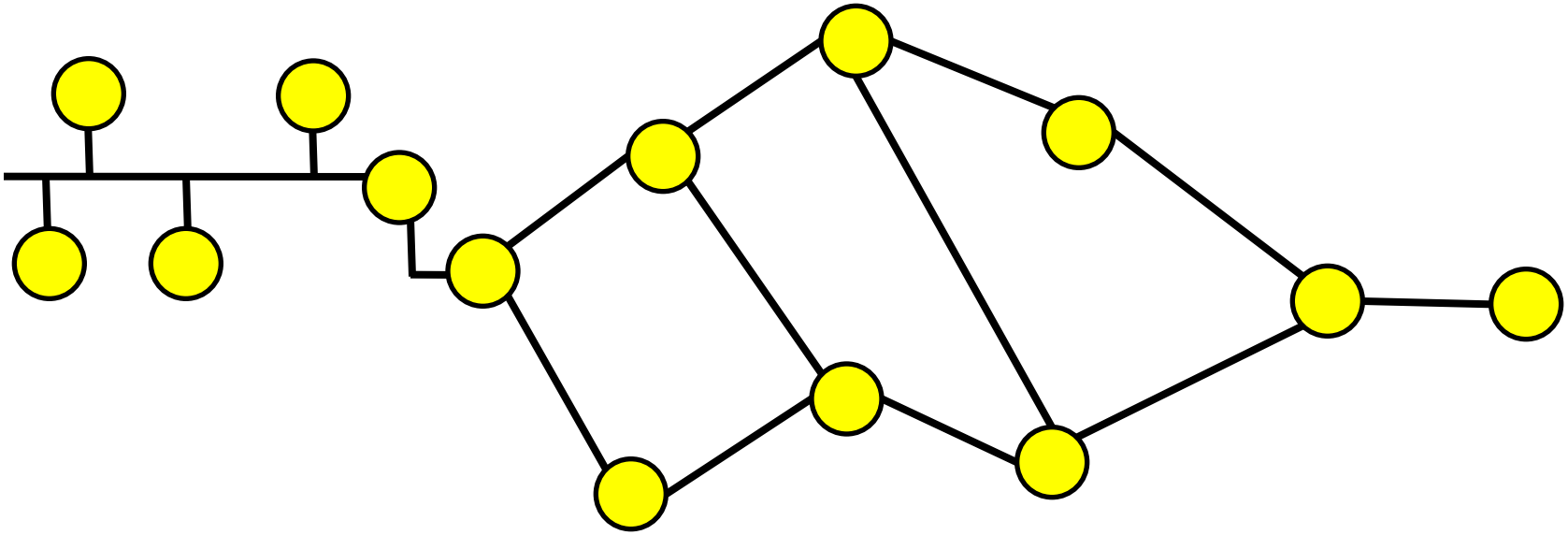


One direct link between two terminals

= Terminals or Stations

Data units = Frames

Naming at the Network Layer

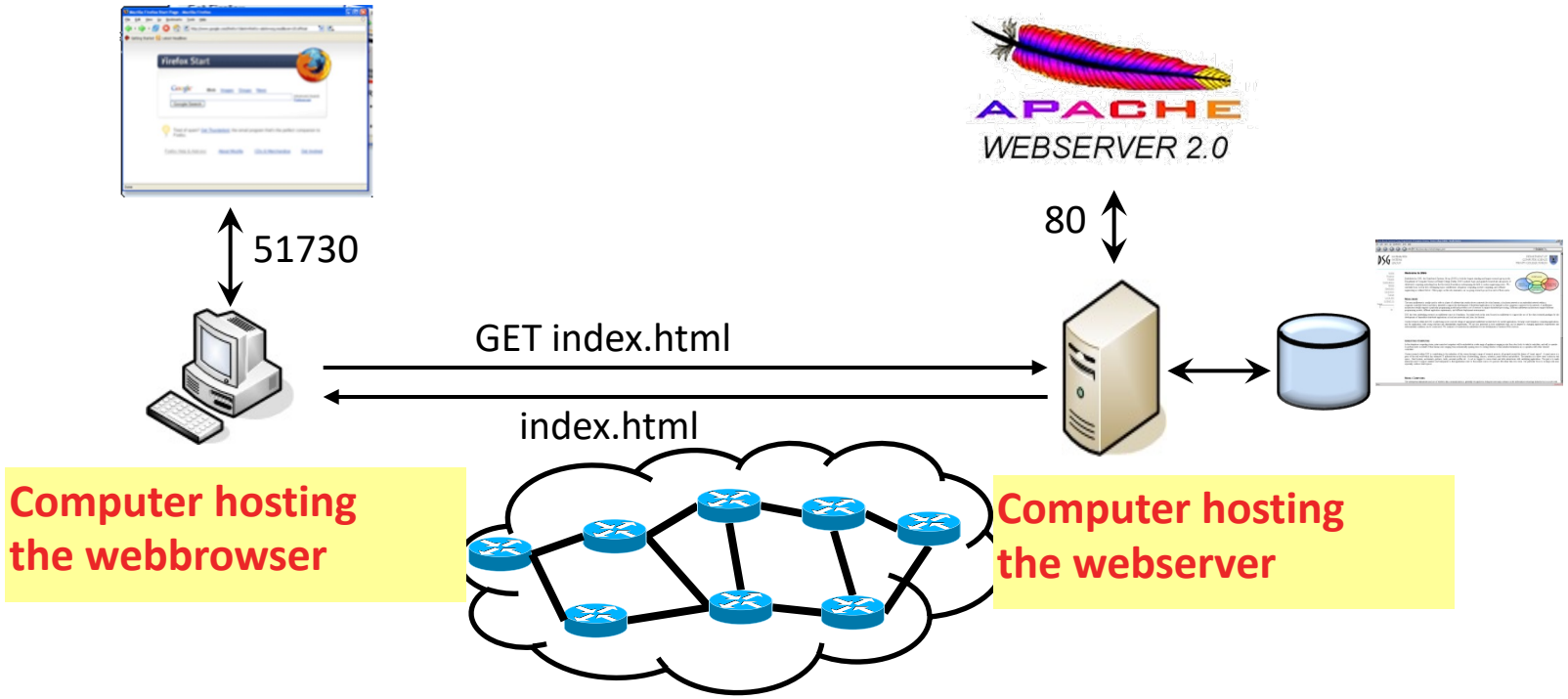


= Nodes of a graph

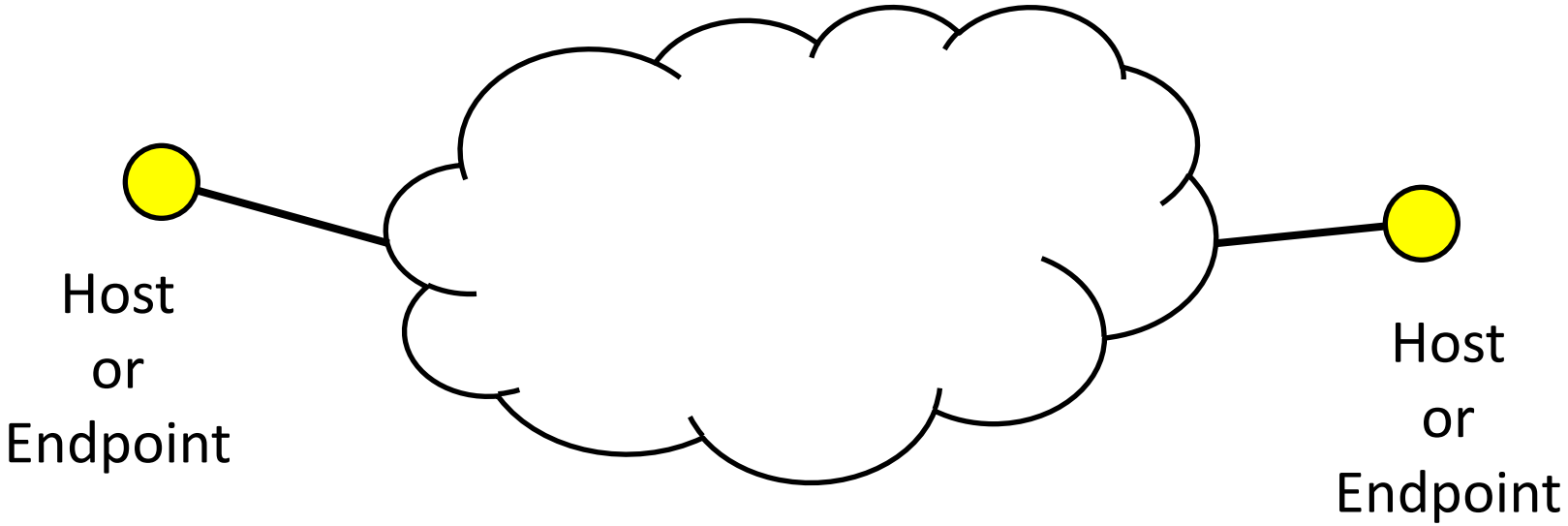
Data units = Packets

Any number of edges between two nodes

Naming at the Transport Layer



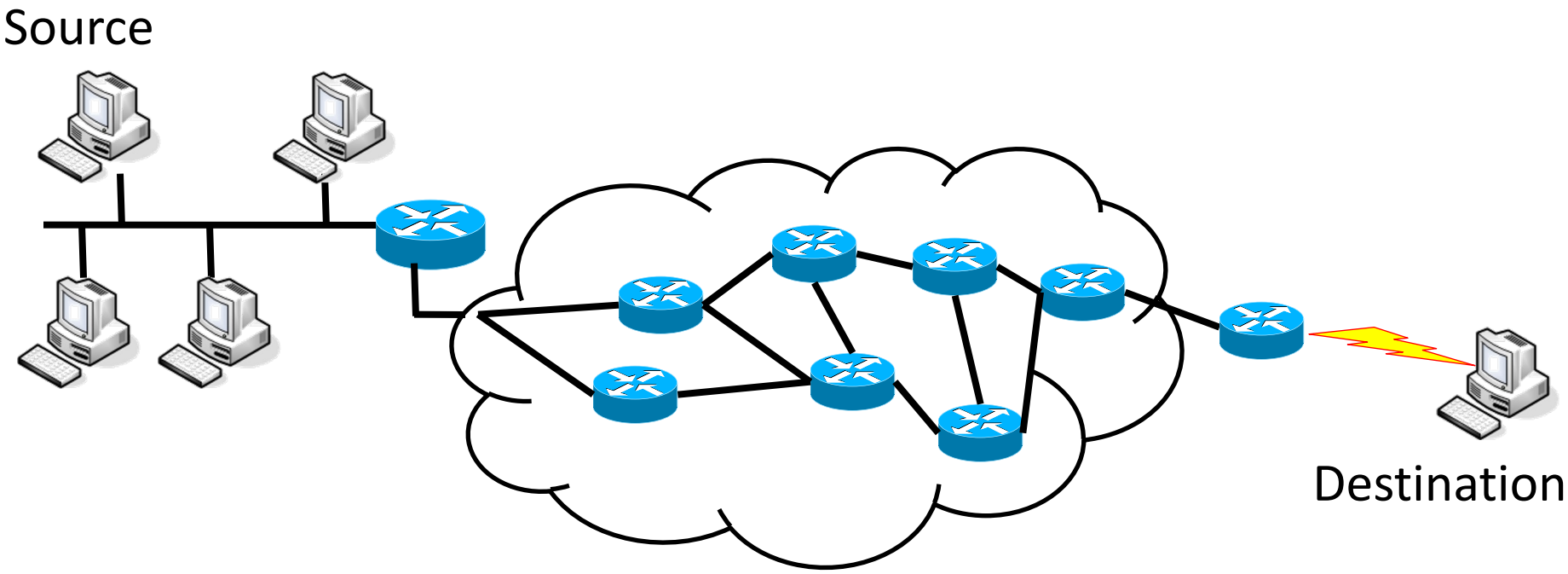
Naming at the Transport Layer



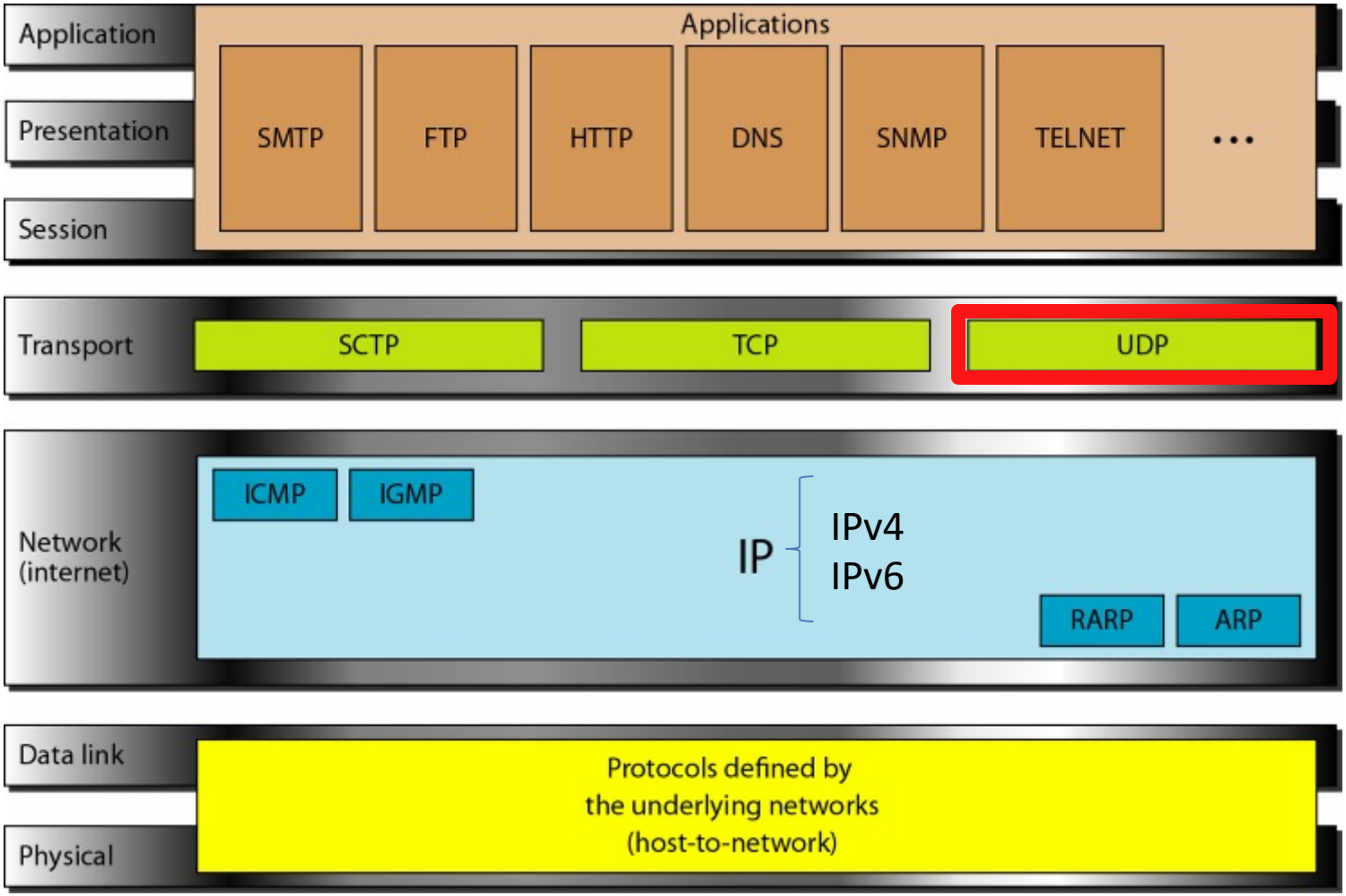
= Host

Data units = Segments or Datagrams

Task of the Network Layer

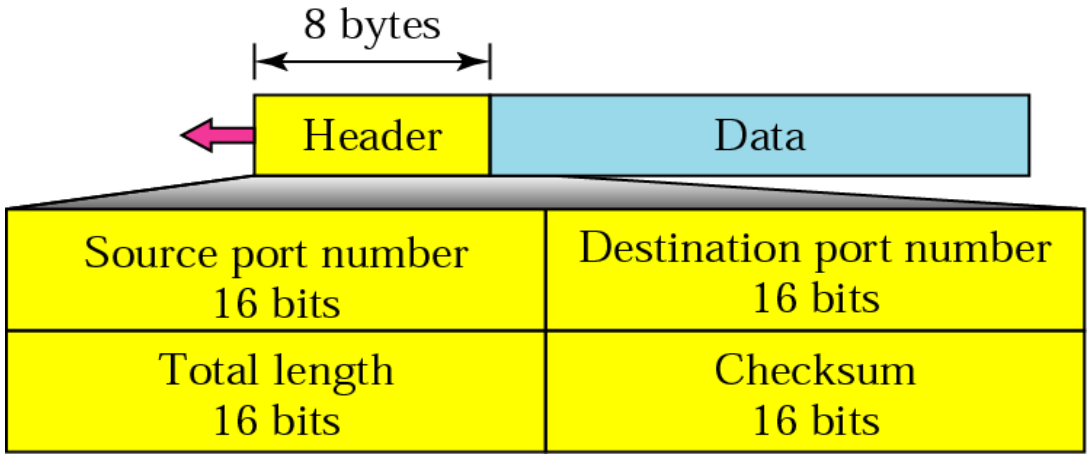


Protocols in the OSI Model



* Figure is courtesy of B. Forouzan

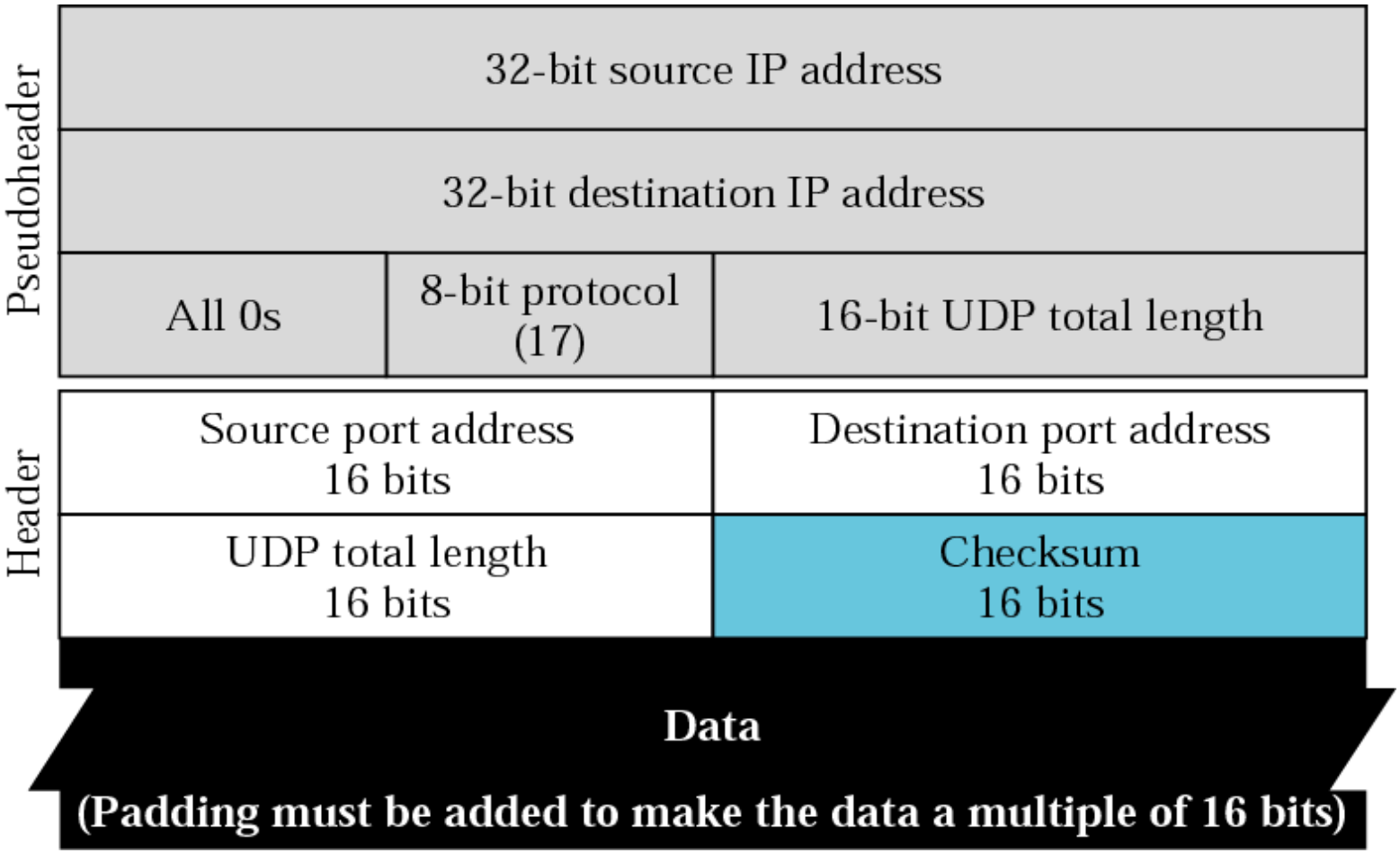
User Datagram Protocol (UDP)



- UDP is a connectionless, unreliable protocol
  - No flow and error control
  - Port numbers are used to multiplex data
- Calculation of checksum & its inclusion in datagram are optional.
- Convenient transport-layer protocol for applications that provide their own flow and error control
  - Also used by multimedia applications.

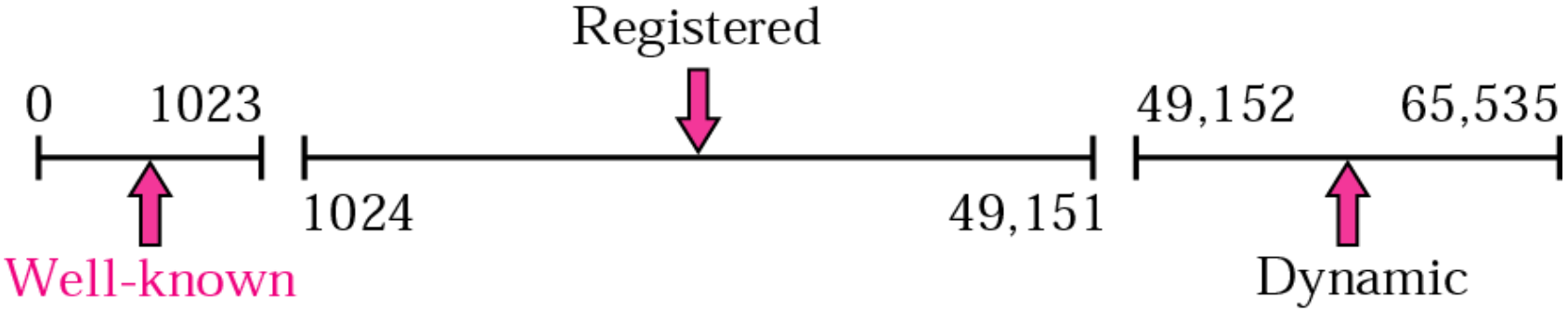
* Figure is courtesy of B. Forouzan

Pseudo-Header for Checksum



* Figure is courtesy of B. Forouzan

Well-Known Port Numbers

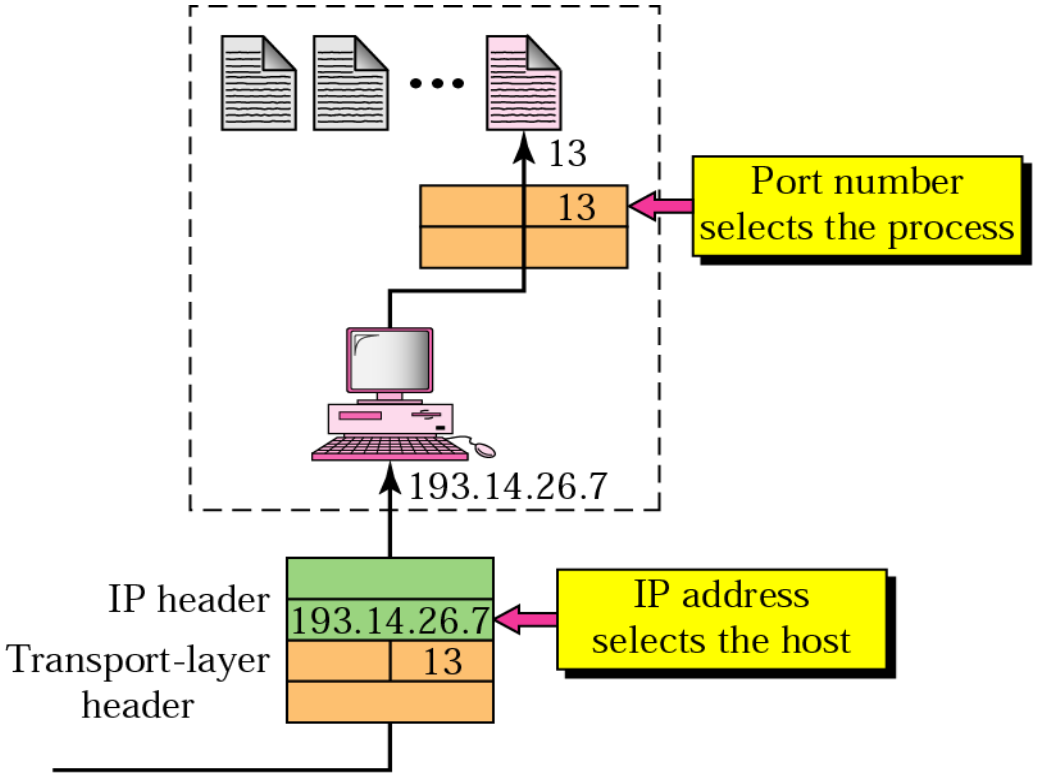


- Assigned by Internet Assigned Numbers Authority (IANA)
- 3 Categories of Ports:
  - Well-known Ports: 0 – 1023 (restricted access)
  - Registered Ports: 1024 – 49151
  - Dynamic/Private Ports: 49152 – 65535

* Figure is courtesy of B. Forouzan

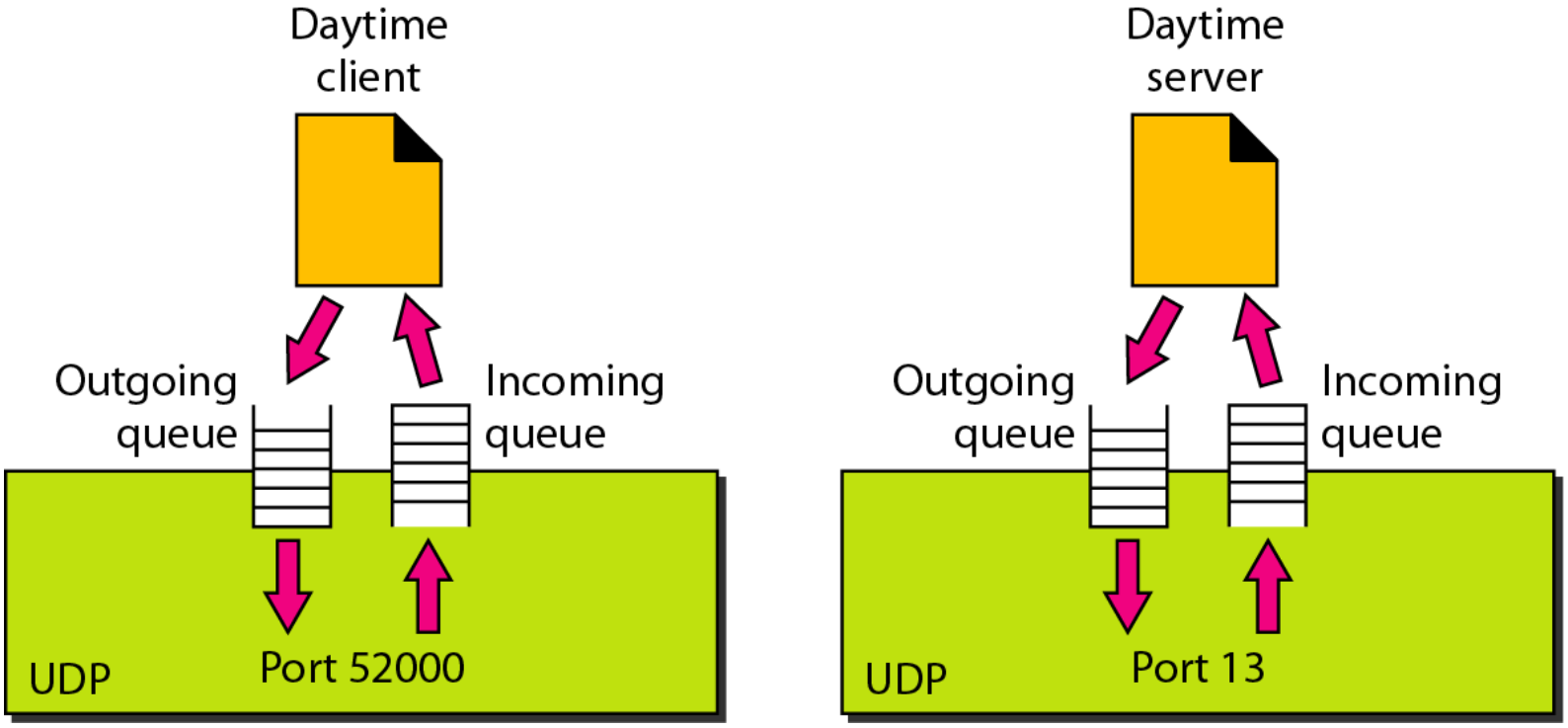
IP Addresses & Port Numbers

- IP Addresses determine the host
- Port Numbers determine the buffer in the OS



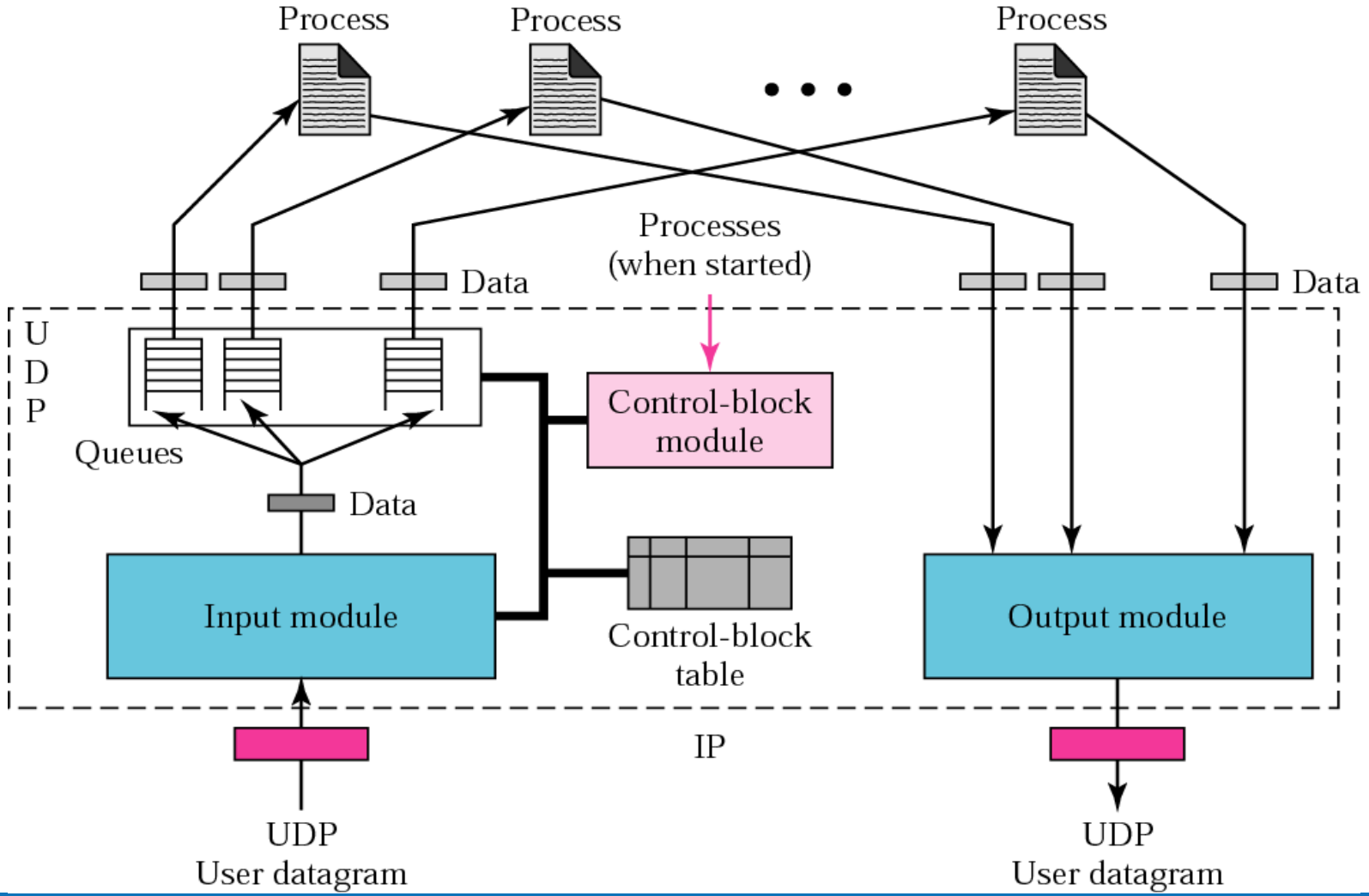
* Figure is courtesy of B. Forouzan

Queuing in UDP



* Figure is courtesy of B. Forouzan

Processes and UDP Queues



UDP Queue Example I

State	*Process ID*	*Port Number*	*Queue Number*
IN-USE	2,345	52,010	34
IN-USE	3,422	52,011	
FREE			
IN-USE	4,652	52,012	38
FREE			

State	*Process ID*	*Port Number*	*Queue Number*
IN-USE	2,345	52,010	34
IN-USE	3,422	52,011	
IN-USE	**4,978**	**52,014**	
IN-USE	4,652	52,012	38
FREE			

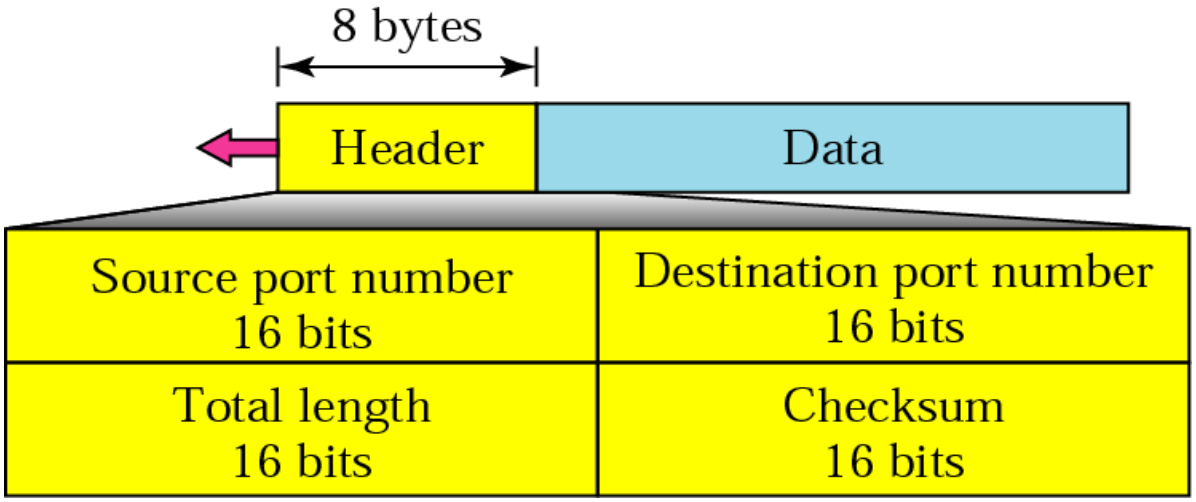
UDP Queue Example II

State	*Process ID*	*Port Number*	*Queue Number*
IN-USE	2,345	52,010	34
IN-USE	3,422	52,011	**43**
IN-USE	4,978	52,014	
IN-USE	4,652	52,012	38
FREE			

- Packet for Port 52011 arrives
  - Queue is created and packet is queued
- Packet for Port 53255 arrives
  - Packet is dropped

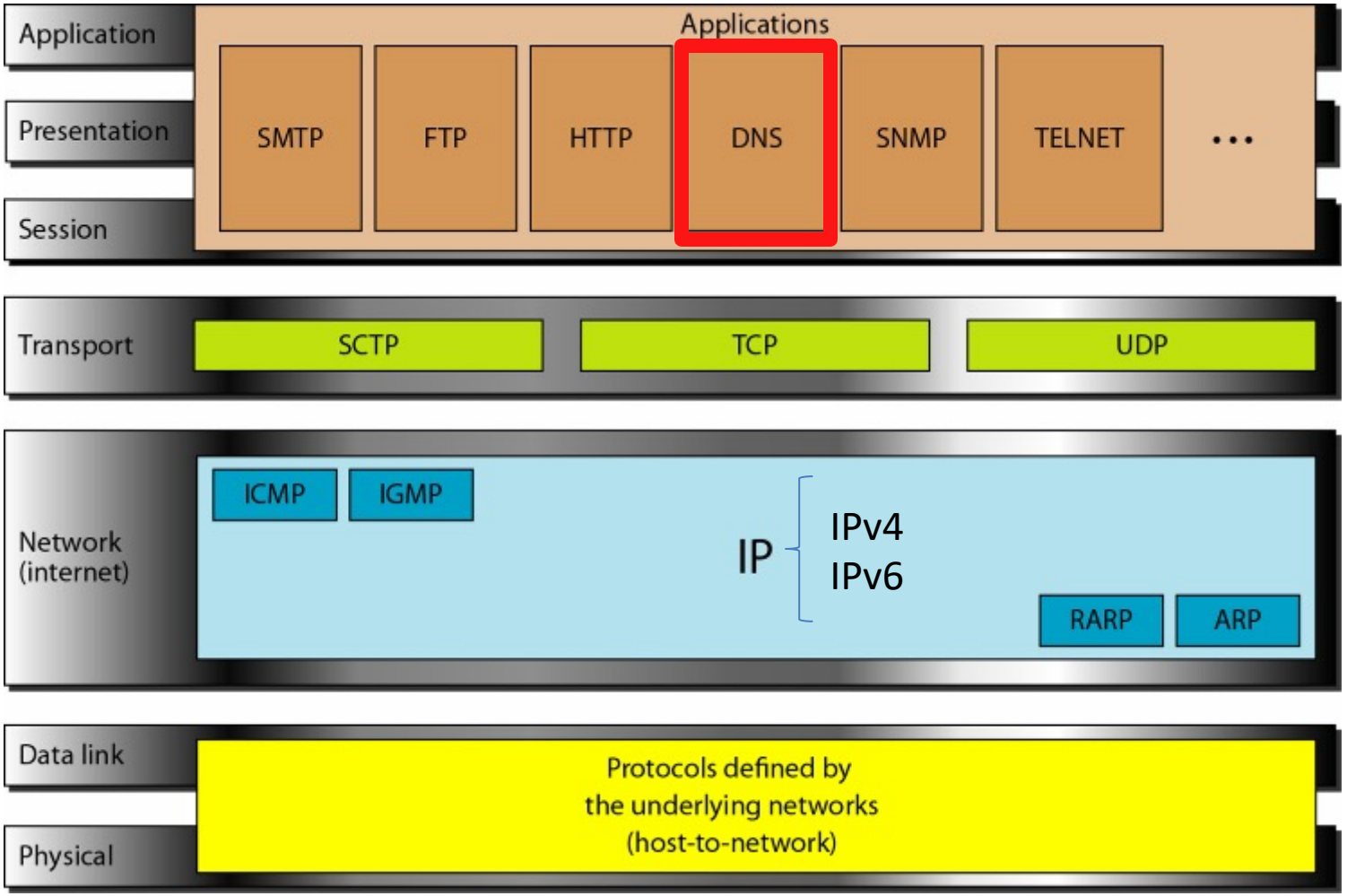
User Datagram Protocol (UDP)

- Connectionless
- Unreliable
  - No flow or error control
- Small Header:



* Figure is courtesy of B. Forouzan

Protocols in the OSI Model



* Figure is courtesy of B. Forouzan

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Distributed Name Service (DNS)

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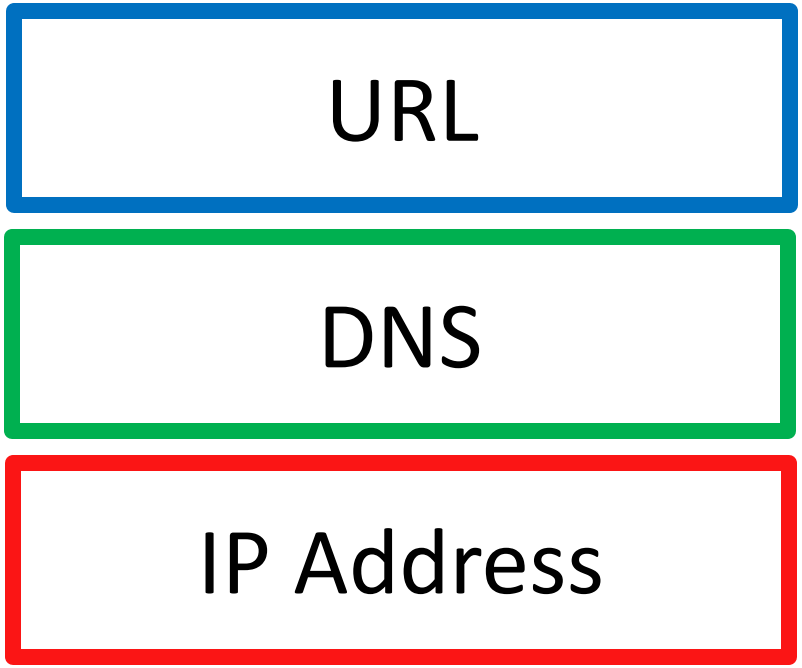
URLs to Names to Addresses



http://www.wiki.com/index.html

www.wiki.com

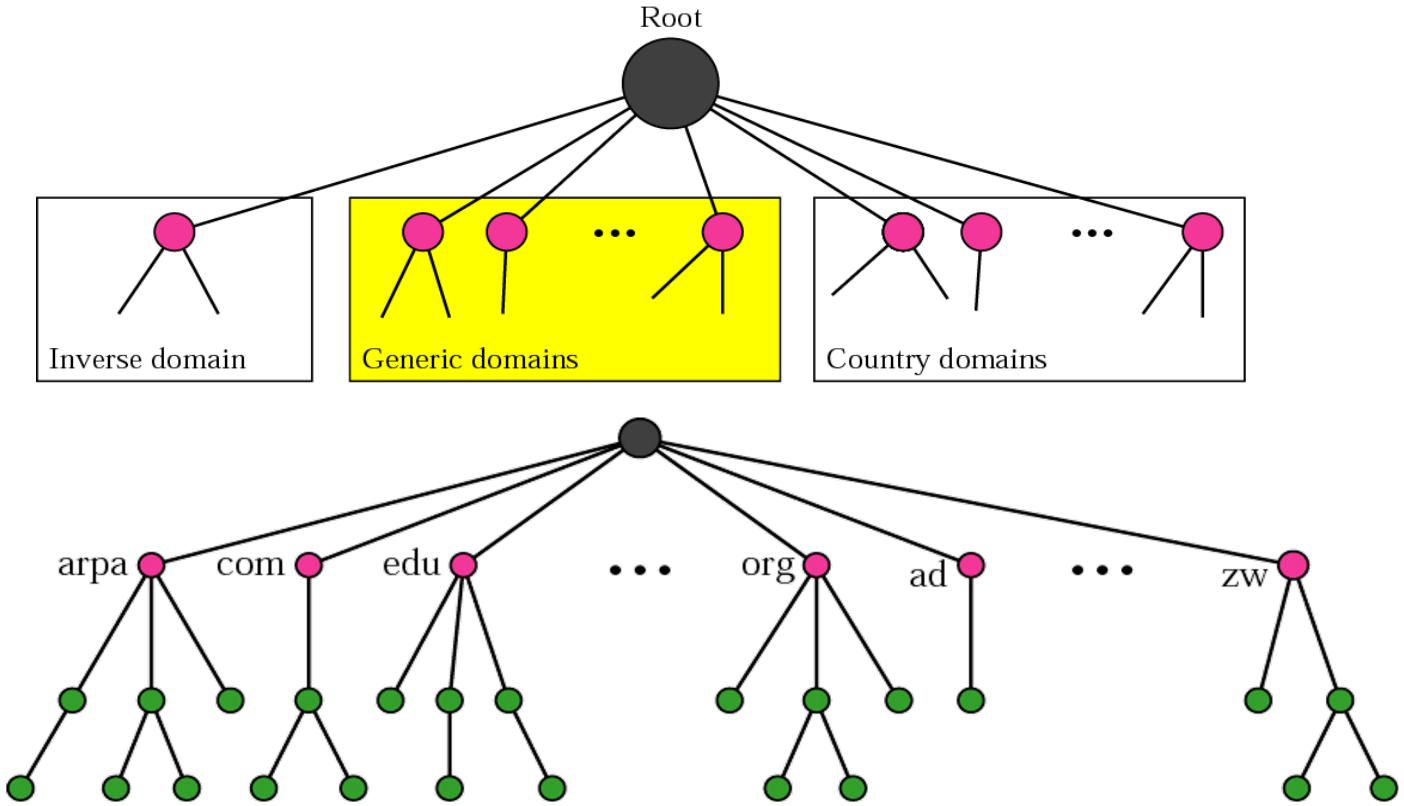
66.96.149.1

*URL = Uniform Resource Locator

Domain Name Space

- Association between names and IP addresses

  www.dsg.scss.tcd.ie - 134.226.36.14



* Figure is courtesy of B. Forouzan

Domain Name Space

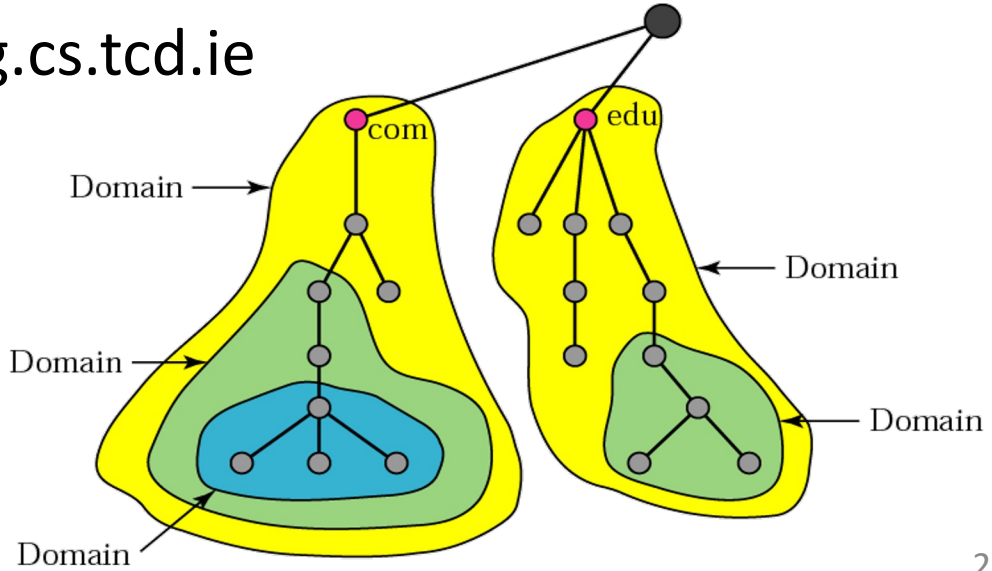
- Association between names and IP addresses

  www.dsg.scss.tcd.ie - 134.226.36.14

- Each domain may contain a number of sub-domains e.g.

  tcd.ie contains cs.tcd.ie, mee.tcd.ie

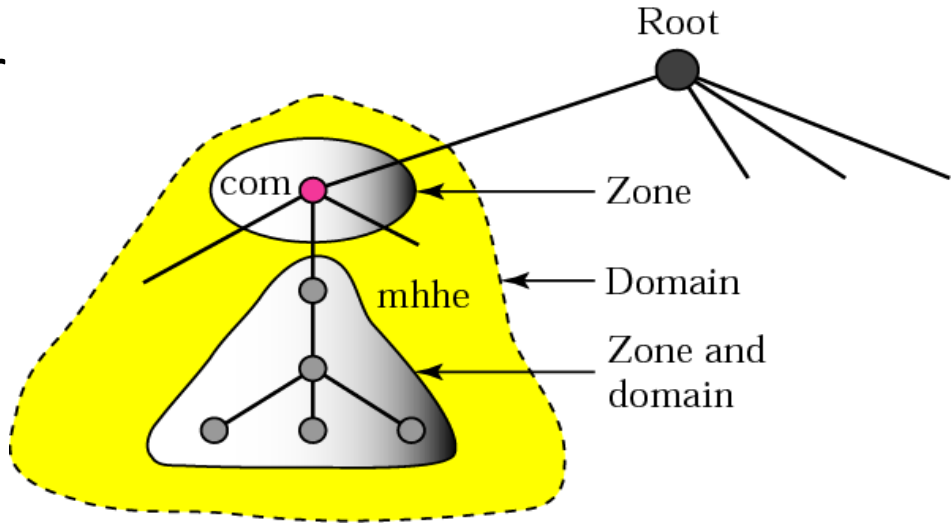
  cs.tcd.ie contains dsg.cs.tcd.ie

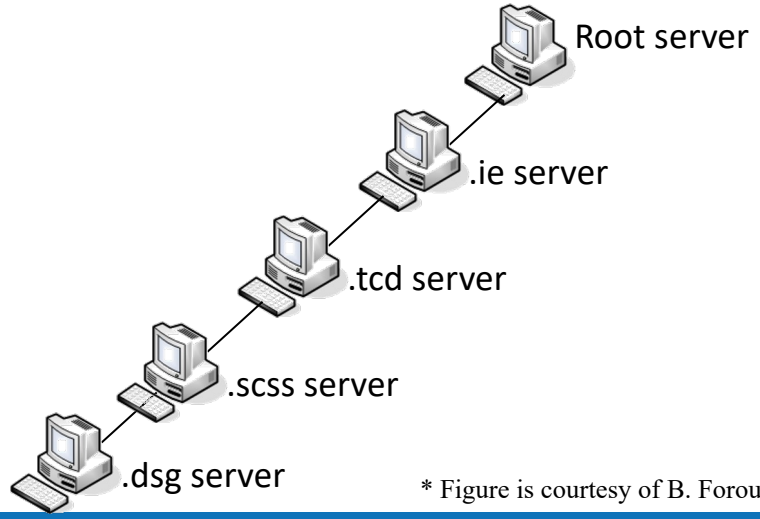


* Figure is courtesy of B. Forouzan

Hierarchy of Name Servers

- Every zone has a DNS server
- DNS server maintain lists of
  - Nodes in the zone
  - References to servers of zones

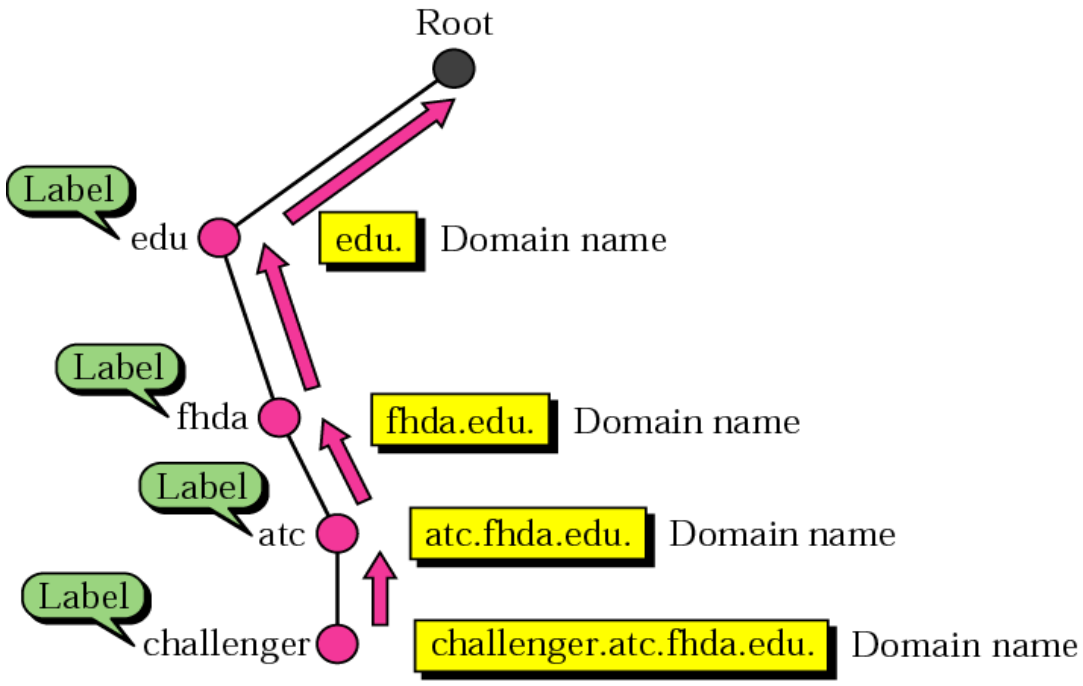




* Figure is courtesy of B. Forouzan

Domain Names and Labels

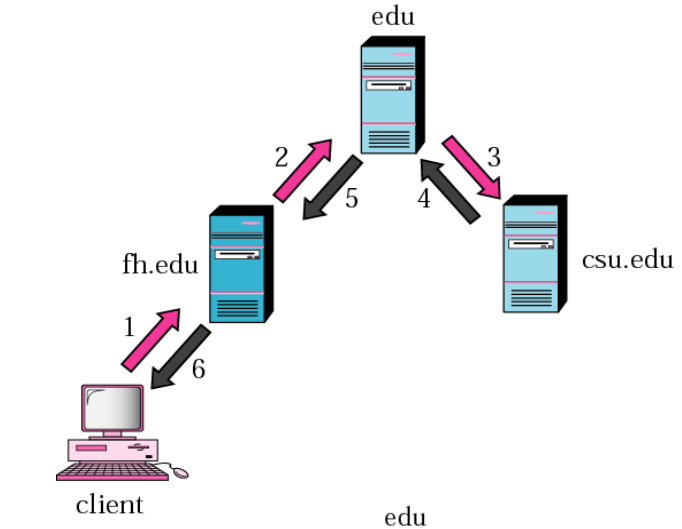
- A domain name consist of a number of labels



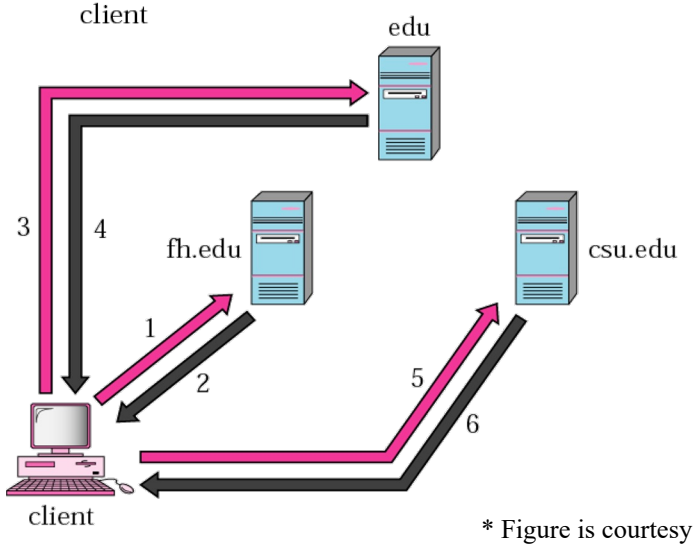
* Figure is courtesy of B. Forouzan

Name Resolution

- Recursive resolution

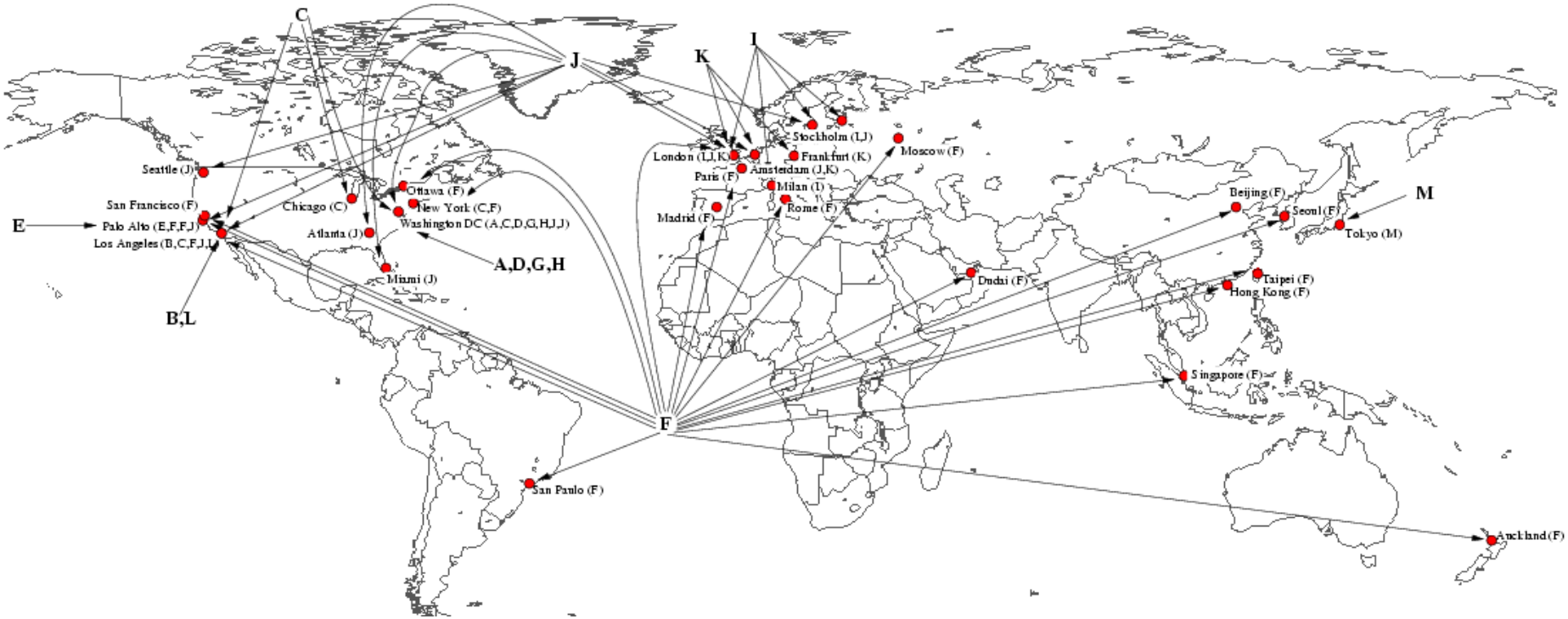


- Iterative resolution



* Figure is courtesy of B. Forouzan

DNS Root Servers - Anycast



* Figure is courtesy of CAIDA

root.zone file

```
e.dns.id.               172800  IN      A       103.19.177.177
e.dns.id.               172800  IN      AAAA    2001:df5:4000:4:0:0:0:4
ie.                     172800  IN      NS      a.ns.ie.
ie.                     172800  IN      NS      b.ns.ie.
ie.                     172800  IN      NS      c.ns.ie.
ie.                     172800  IN      NS      d.ns.ie.
ie.                     172800  IN      NS      e.ns.ie.
ie.                     172800  IN      NS      f.ns.ie.
ie.                     172800  IN      NS      g.ns.ie.
ie.                     172800  IN      NS      h.ns.ie.
IE.                     86400   IN      DS      25105 8 2 3883D06014FA40518A53C70442C3601A271C0F96
IE.                     86400   IN      RRSIG   DS 8 1 86400 20151206050000 20151126040000 62530 .
hHchxthV1+mIjN7sPVl27PSK04OJkegzc2Pib9+4q6bXYU3L6JPS4oXhsBqhSEA/WP7MvWemL0hSiETvuo3b8CAoMr0oTQnspb
ie.                     86400   IN      NSEC    ifm. NS DS RRSIG NSEC
ie.                     86400   IN      RRSIG   NSEC 8 1 86400 20151206050000 20151126040000 62536
QXF5lQuk4H1casAa0GTKv2Mueizyb8p06x3RU2BtQBG6O9nhU9dPHIN8AA6NTQaUTleBBwAaAF3aUh37Q6r2K6+x8gsj46nxsV
a.ns.ie.                172800  IN      A       77.72.72.44
a.ns.ie.                172800  IN      AAAA    2a01:4b0:0:0:0:0:0:3
b.ns.ie.                172800  IN      A       77.72.72.34
b.ns.ie.                172800  IN      AAAA    2a01:4b0:0:0:0:0:0:2
c.ns.ie.                172800  IN      A       194.146.106.98
c.ns.ie.                172800  IN      AAAA    2001:67c:1010:25:0:0:0:53
d.ns.ie.                172800  IN      A       77.72.229.245
d.ns.ie.                172800  IN      AAAA    2a01:3f0:0:309:0:0:0:53
e.ns.ie.                172800  IN      A       199.19.2.1
e.ns.ie.                172800  IN      AAAA    2001:500:93:0:0:0:0:1
f.ns.ie.                172800  IN      A       199.19.3.1
```

.ie Servers

Name Servers

Host Name	IP Address(es)
e.ns.ie	199.19.2.1 2001:500:93:0:0:0:0:1
b.ns.ie	77.72.72.34 2a01:4b0:0:0:0:0:0:2
g.ns.ie	192.111.39.100 2001:7c8:2:a:0:0:0:64
c.ns.ie	194.146.106.98 2001:67c:1010:25:0:0:0:53
d.ns.ie	77.72.229.245 2a01:3f0:0:309:0:0:0:53
f.ns.ie	199.19.3.1 2001:500:95:0:0:0:0:1
a.ns.ie	77.72.72.44 2a01:4b0:0:0:0:0:0:3
h.ns.ie	192.93.0.4 2001:660:3005:1:0:0:1:2

* Information from https://www.iana.org/domains/root/db/ie.html

ipconfig /all

```
Wireless LAN adapter WiFi:

   Connection-specific DNS Suffix  . : scss.tcd.ie
   Description . . . . . . . . . . . : Intel(R) Dual Band Wireless-AC 7260
   Physical Address. . . . . . . . . : 28-B2-BD-A0-C0-A3
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   IPv6 Address. . . . . . . . . . . : 2001:770:10:203:c018:a372:1daa:424f(Prefe
rred)
   Temporary IPv6 Address. . . . . . : 2001:770:10:203:f0c0:4f35:6fd5:90d4(Prefe
rred)
   Link-local IPv6 Address . . . . . : fe80::c018:a372:1daa:424f%3(Preferred)
   IPv4 Address. . . . . . . . . . . : 134.226.62.20(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Lease Obtained. . . . . . . . . . : 26 November 2015 11:11:18
   Lease Expires . . . . . . . . . . : 26 November 2015 14:26:16
   Default Gateway . . . . . . . . . : fe80::c664:13ff:fe42:7a42%3
                                       134.226.62.254
   DHCP Server . . . . . . . . . . . : 134.226.32.58
   DHCPv6 IAID . . . . . . . . . . . : 52998845
   DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-1B-DD-F3-17-28-B2-BD-A0-C0-A3

   DNS Servers . . . . . . . . . . . : 134.226.32.57
                                       134.226.56.13
```

nslookup

```
C:\Users\sweber>nslookup
Default Server:  challenger.cs.tcd.ie
Address:  134.226.32.57

> set type=NS
> tcd.ie
Server:  challenger.cs.tcd.ie
Address:  134.226.32.57

Non-authoritative answer:
tcd.ie  nameserver = int-ns1.tcd.ie
tcd.ie  nameserver = int-ns2.tcd.ie

int-ns1.tcd.ie  internet address = 134.226.251.108
int-ns2.tcd.ie  internet address = 134.226.251.109
> scss.tcd.ie
Server:  challenger.cs.tcd.ie
Address:  134.226.32.57

scss.tcd.ie      nameserver = ns2.scss.tcd.ie
scss.tcd.ie      nameserver = ns.scss.tcd.ie
ns.scss.tcd.ie   internet address = 134.226.32.58
ns.scss.tcd.ie   AAAA IPv6 address = 2001:770:10:200:e8e0:c8ff:fec5:6b63
ns2.scss.tcd.ie internet address = 134.226.56.13
ns2.scss.tcd.ie AAAA IPv6 address = 2001:770:10:200:a0dd:c1ff:fe89:ed50
```

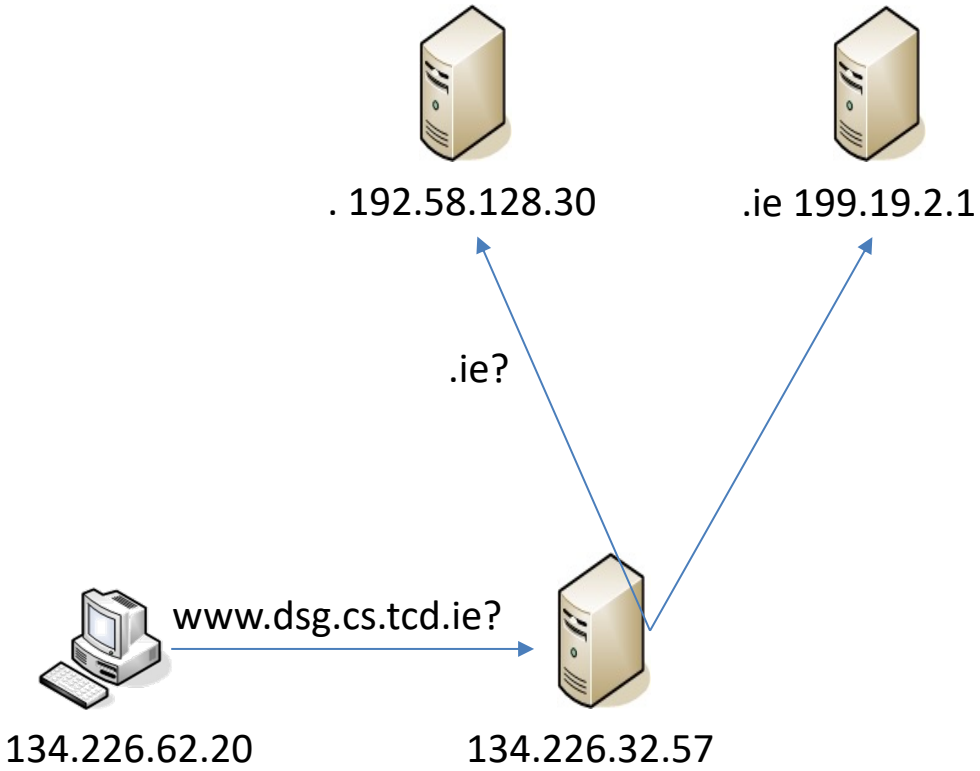
SOA – DNS server configuration

Type	Meaning	Value
SOA	Start of Authority	Parameters for this zone
A	IP address of a host	32-Bit integer
MX	Mail exchange	Priority, domain willing to accept e-mail
NS	Name Server	Name of a server for this domain
CNAME	Canonical name	Domain name

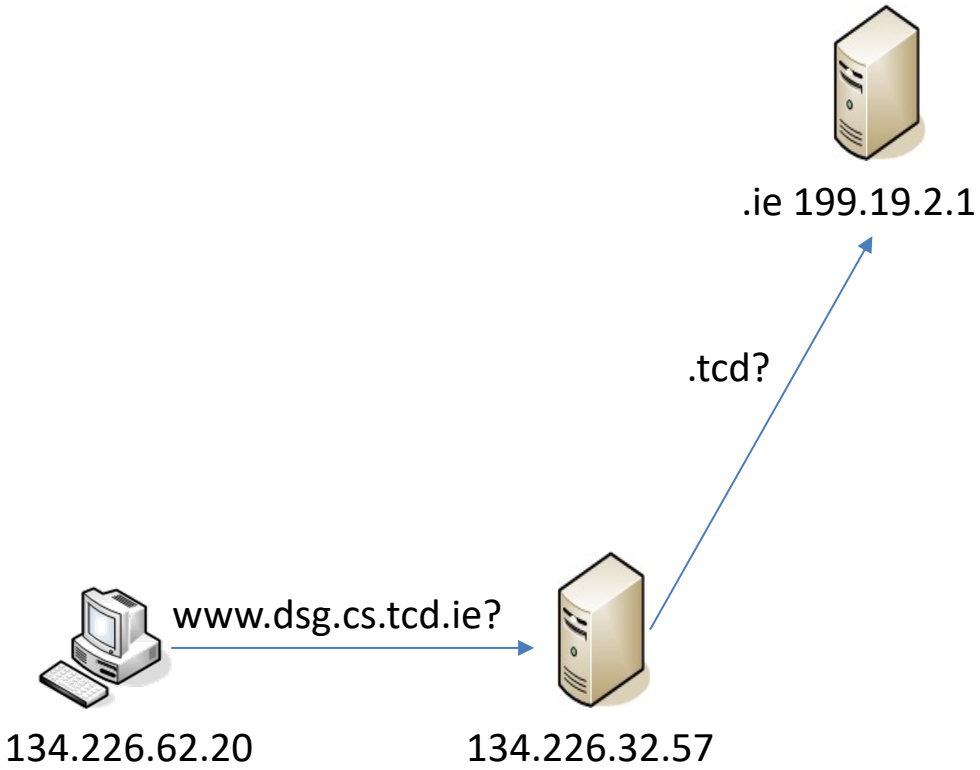
```
@           IN      SOA     ns1.dsg.cs.tcd.ie. dsgadmin.cs.tcd.ie. (
            IN      NS      ns1.dsg.cs.tcd.ie.
            IN      NS      ns2.dsg.cs.tcd.ie.

www         IN      A       134.226.36.1
dilbert     IN      CNAME   computerA
dogbert     IN      A       134.226.36.2
            IN      A       134.226.36.3
```

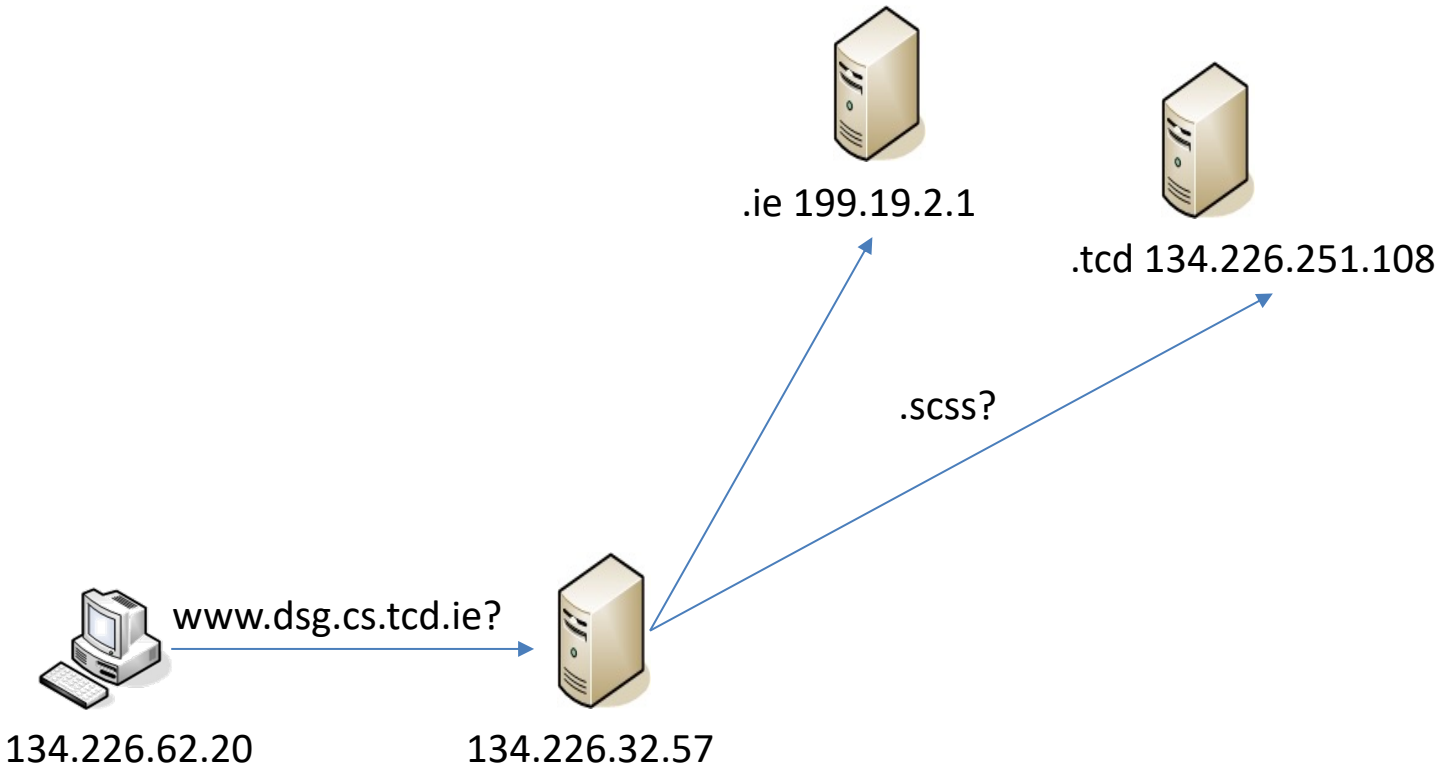
Lookup of www.dsg.scss.tcd.ie.



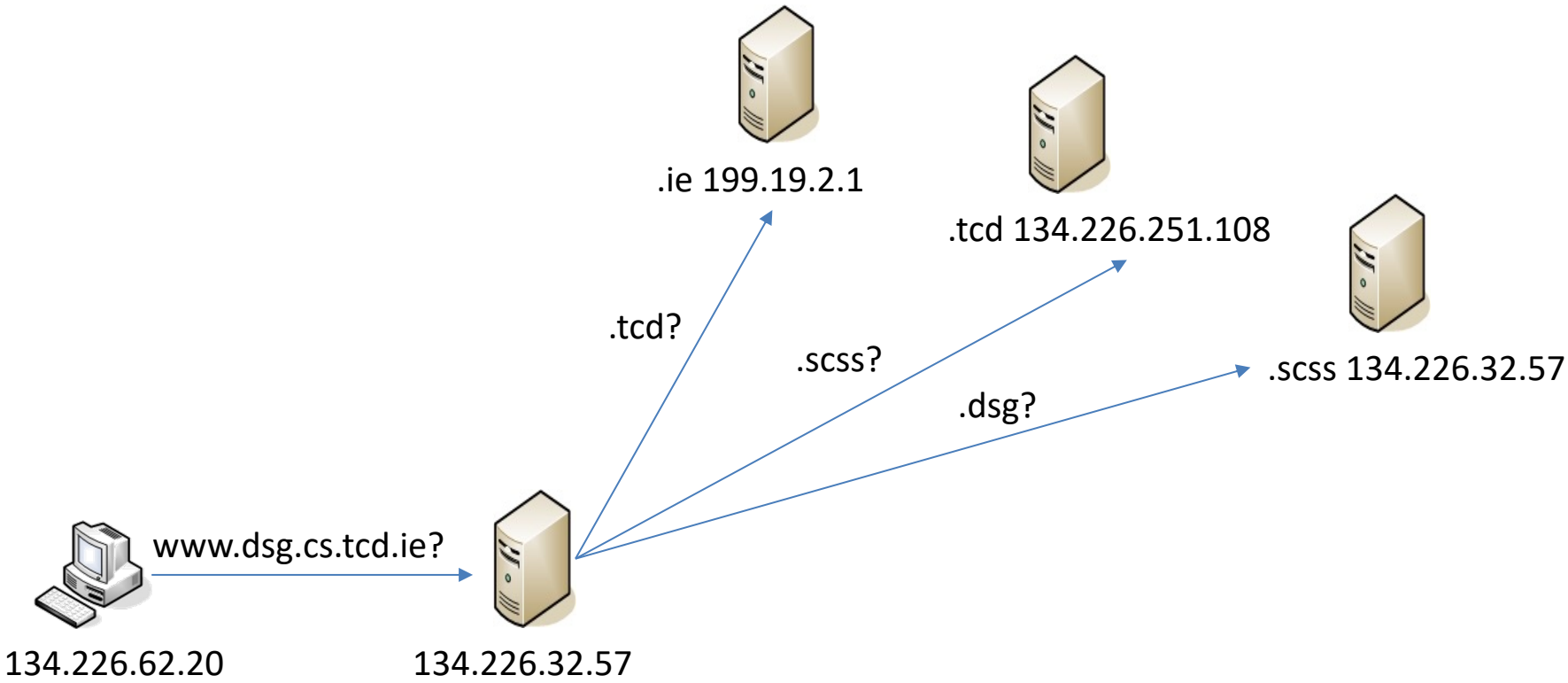
Lookup of www.dsg.scss.tcd.ie.



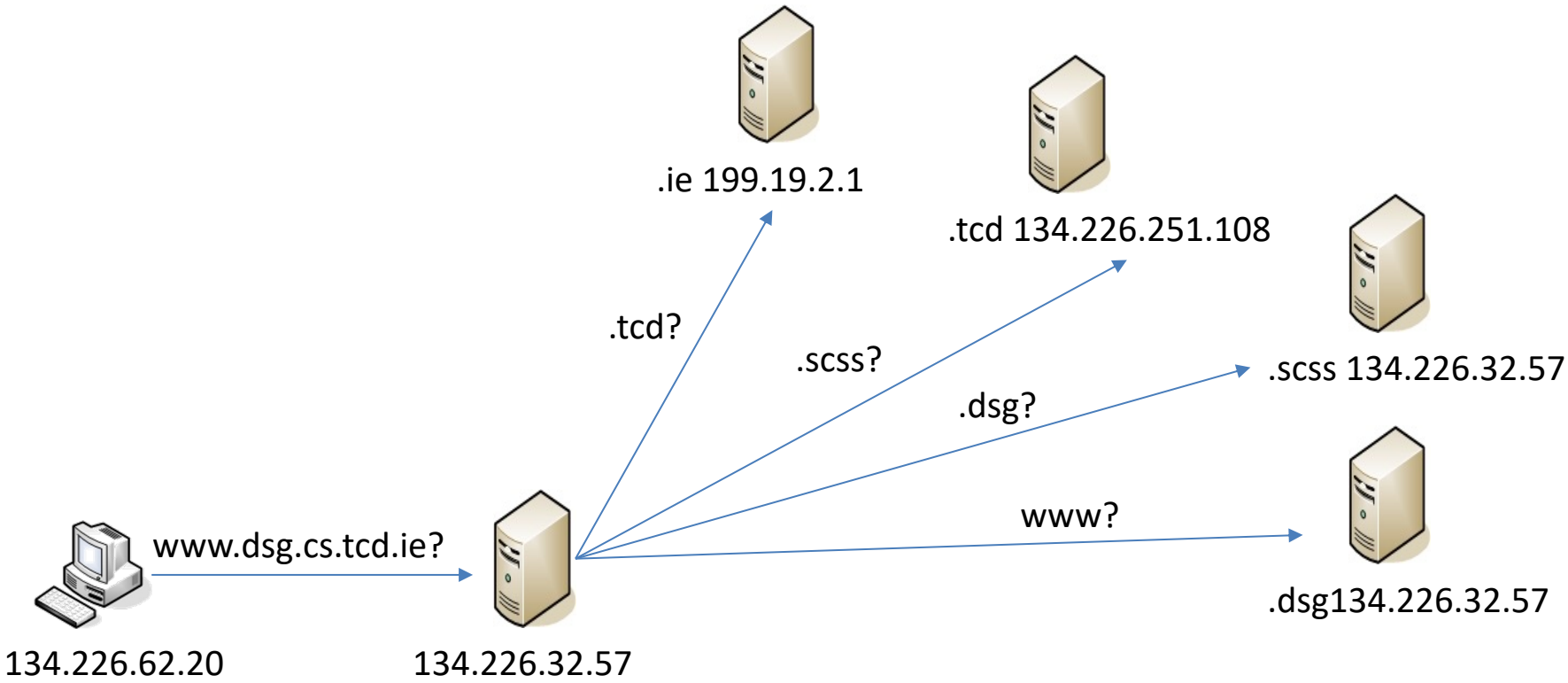
Lookup of www.dsg.scss.tcd.ie.



Lookup of www.dsg.scss.tcd.ie.

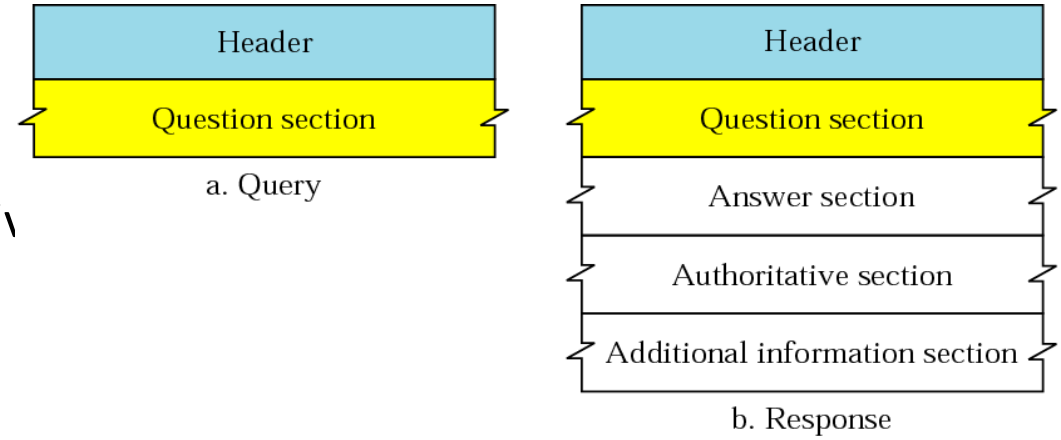


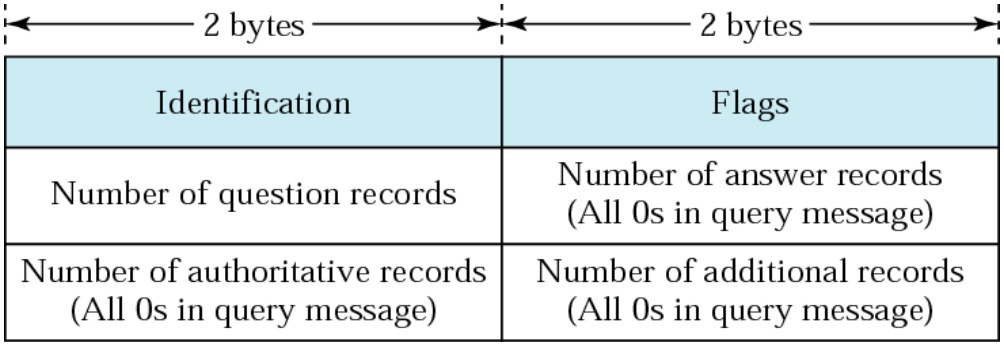
Lookup of www.dsg.scss.tcd.ie.



Query and Response Messages

- Two types of replies:
  - Authoritive answers
  - Cached or unauthoritiv
- 6-byte header





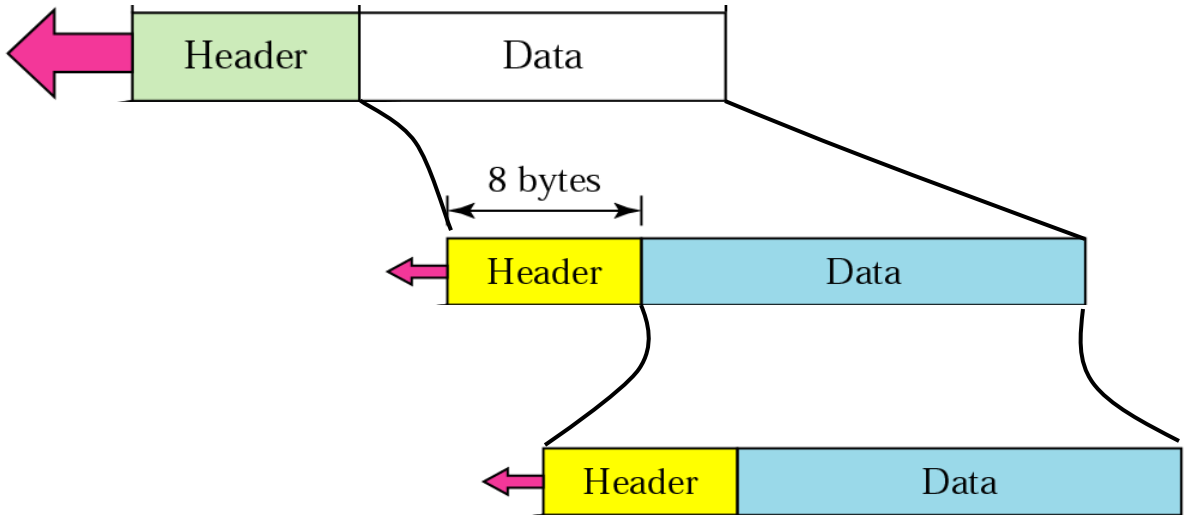
* Figure is courtesy of B. Forouzan

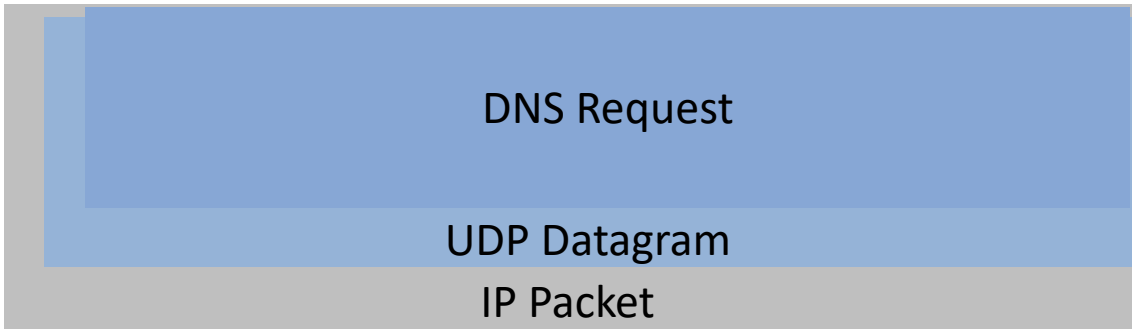
DNS Request

IP Packet

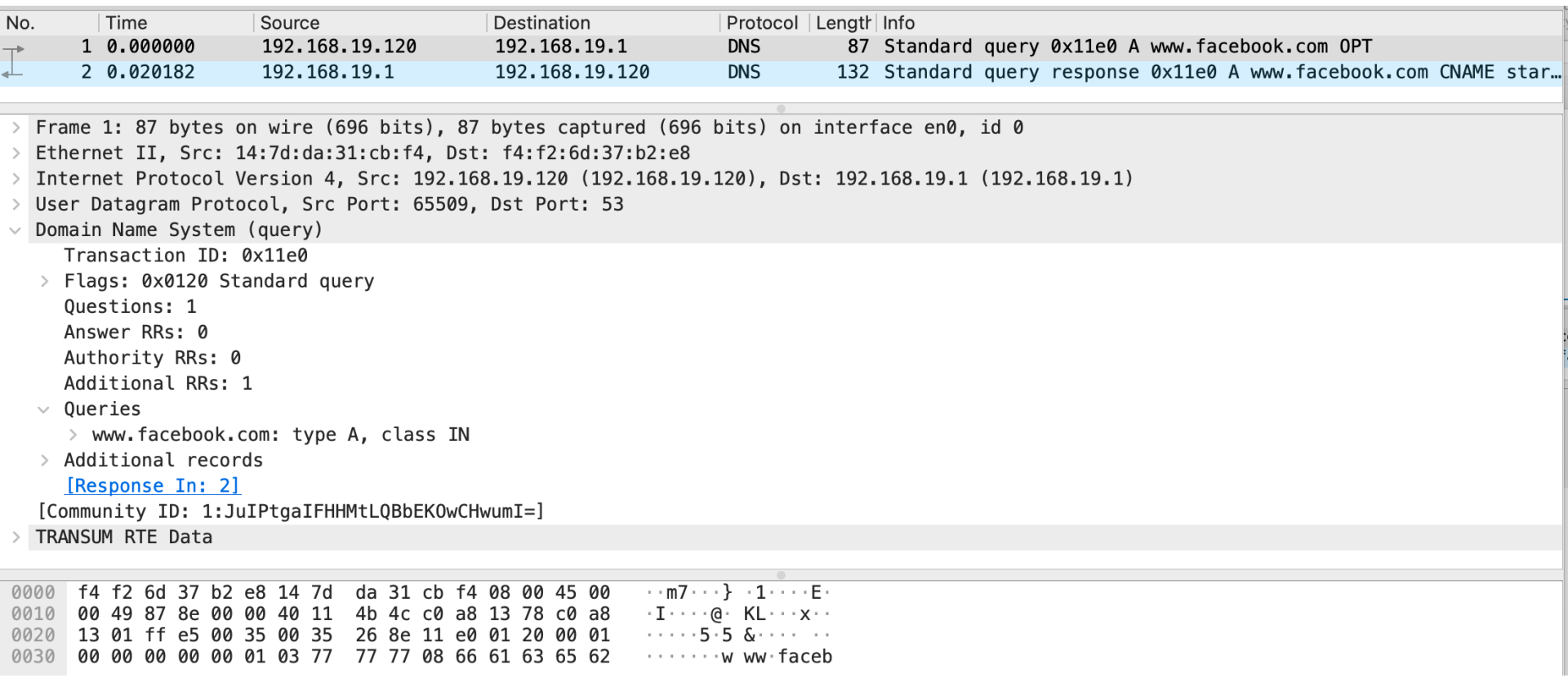
UDP Datagram

DNS Request





DNS Query

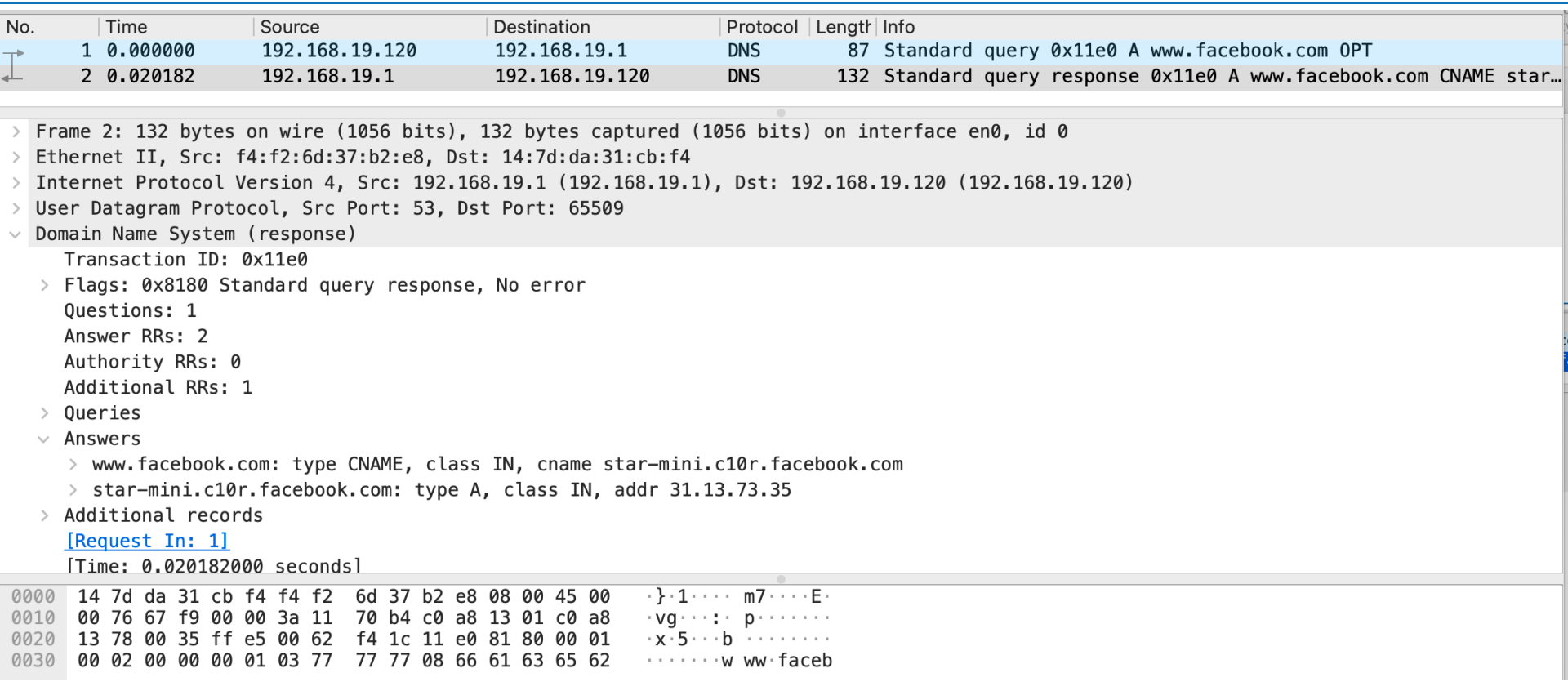


No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.19.120	192.168.19.1	DNS	87	Standard query 0x11e0 A www.facebook.com OPT
2	0.020182	192.168.19.1	192.168.19.120	DNS	132	Standard query response 0x11e0 A www.facebook.com CNAME star…

```
> Frame 1: 87 bytes on wire (696 bits), 87 bytes captured (696 bits) on interface en0, id 0
> Ethernet II, Src: 14:7d:da:31:cb:f4, Dst: f4:f2:6d:37:b2:e8
> Internet Protocol Version 4, Src: 192.168.19.120 (192.168.19.120), Dst: 192.168.19.1 (192.168.19.1)
> User Datagram Protocol, Src Port: 65509, Dst Port: 53
v Domain Name System (query)
    Transaction ID: 0x11e0
  > Flags: 0x0120 Standard query
    Questions: 1
    Answer RRs: 0
    Authority RRs: 0
    Additional RRs: 1
  v Queries
    > www.facebook.com: type A, class IN
  > Additional records
    [Response In: 2]
  [Community ID: 1:JuIPtgaIFHHMtLQBbEKOwCHwumI=]
> TRANSUM RTE Data
```

```
0000  f4 f2 6d 37 b2 e8 14 7d  da 31 cb f4 08 00 45 00   ··m7···} ·1····E·
0010  00 49 87 8e 00 00 40 11  4b 4c c0 a8 13 78 c0 a8   ·I····@· KL···x··
0020  13 01 ff e5 00 35 00 35  26 8e 11 e0 01 20 00 01   ·····5·5 &···· ··
0030  00 00 00 00 00 01 03 77  77 77 08 66 61 63 65 62   ·······w ww·faceb
```

DNS Reply



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.19.120	192.168.19.1	DNS	87	Standard query 0x11e0 A www.facebook.com OPT
2	0.020182	192.168.19.1	192.168.19.120	DNS	132	Standard query response 0x11e0 A www.facebook.com CNAME star…

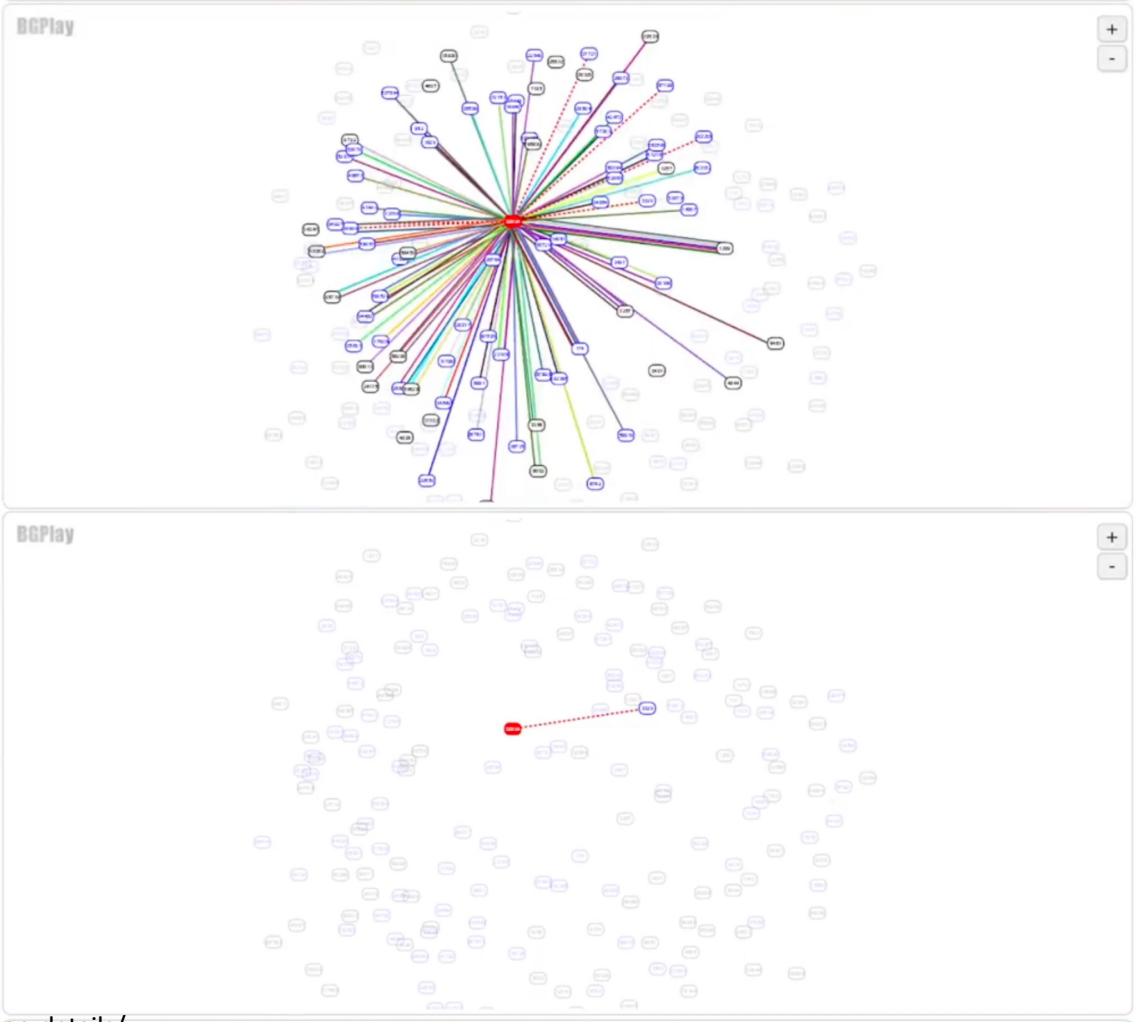
```
> Frame 2: 132 bytes on wire (1056 bits), 132 bytes captured (1056 bits) on interface en0, id 0
> Ethernet II, Src: f4:f2:6d:37:b2:e8, Dst: 14:7d:da:31:cb:f4
> Internet Protocol Version 4, Src: 192.168.19.1 (192.168.19.1), Dst: 192.168.19.120 (192.168.19.120)
> User Datagram Protocol, Src Port: 53, Dst Port: 65509
v Domain Name System (response)
    Transaction ID: 0x11e0
  > Flags: 0x8180 Standard query response, No error
    Questions: 1
    Answer RRs: 2
    Authority RRs: 0
    Additional RRs: 1
  > Queries
  v Answers
    > www.facebook.com: type CNAME, class IN, cname star-mini.c10r.facebook.com
    > star-mini.c10r.facebook.com: type A, class IN, addr 31.13.73.35
  > Additional records
    [Request In: 1]
    [Time: 0.020182000 seconds]
```

```
0000  14 7d da 31 cb f4 f4 f2  6d 37 b2 e8 08 00 45 00   ·}·1···· m7····E·
0010  00 76 67 f9 00 00 3a 11  70 b4 c0 a8 13 01 c0 a8   ·vg···:· p·······
0020  13 78 00 35 ff e5 00 62  f4 1c 11 e0 81 80 00 01   ·x·5···b ········
0030  00 02 00 00 00 01 03 77  77 77 08 66 61 63 65 62   ·······w ww·faceb
```

‘Before’ and ‘After’ snapshots

*Routes to Facebook’s DNS servers

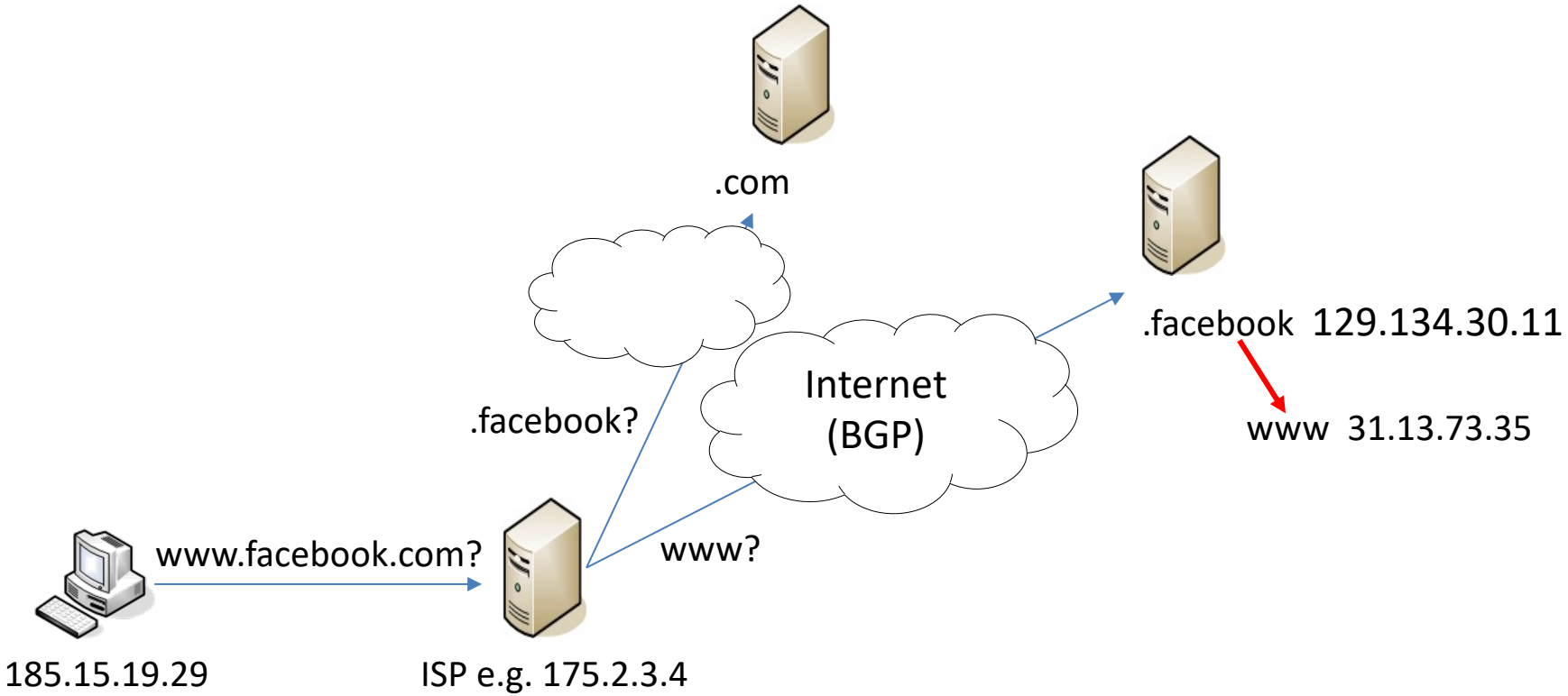
- During one of these routine maintenance jobs, a command was issued with the intention to assess the availability of global backbone capacity, which unintentionally took down all the connections in our backbone network,...
- “our DNS servers disable those BGP advertisements if they themselves can not speak to our data centers”



*https://engineering.fb.com/2021/10/05/networking-traffic/outage-details/

https://twitter.com/GGreg/status/1445105583280070661

Lookup of www.facebook.com.



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

CSU33031 Computer Networks

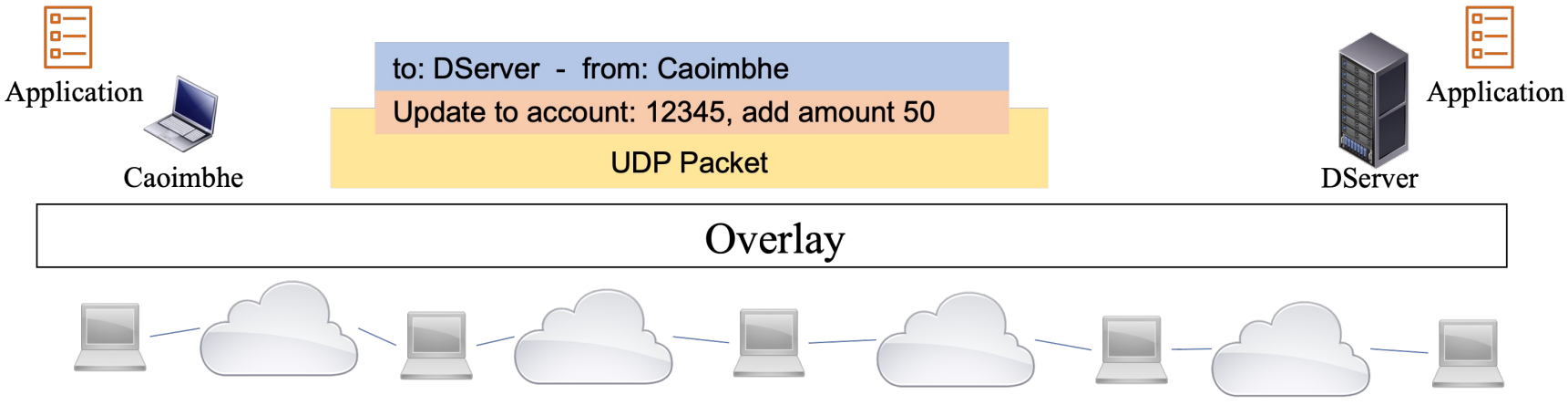
Assignment 2

Stefan Weber

email: sweber@tcd.ie

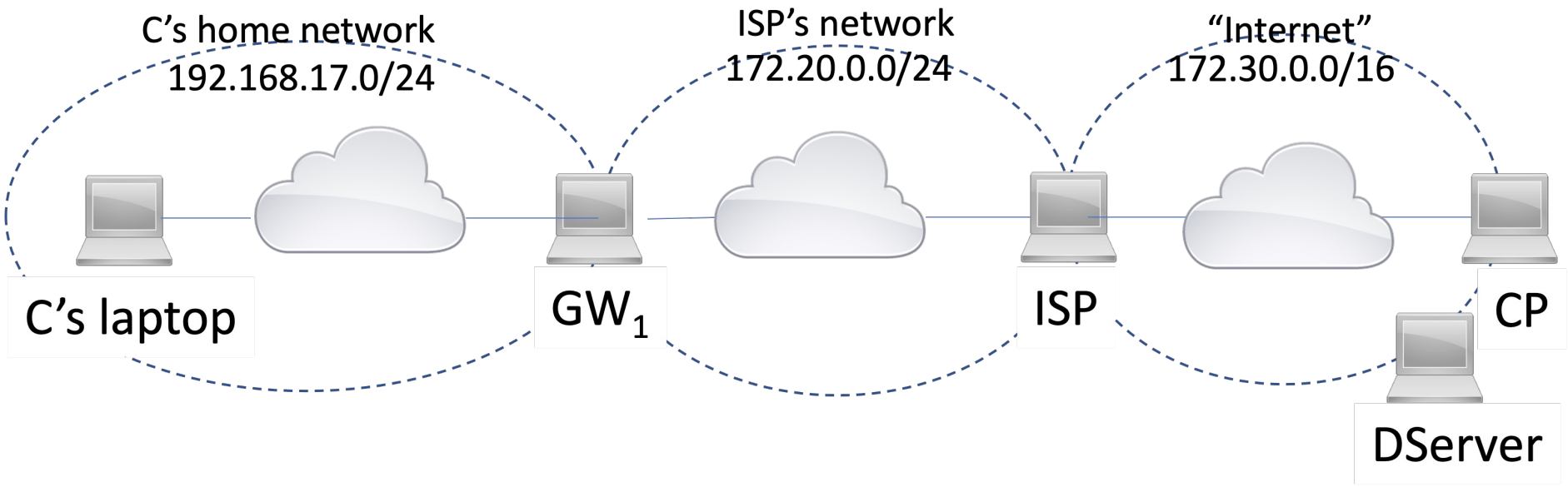
Office: Lloyd 1.41

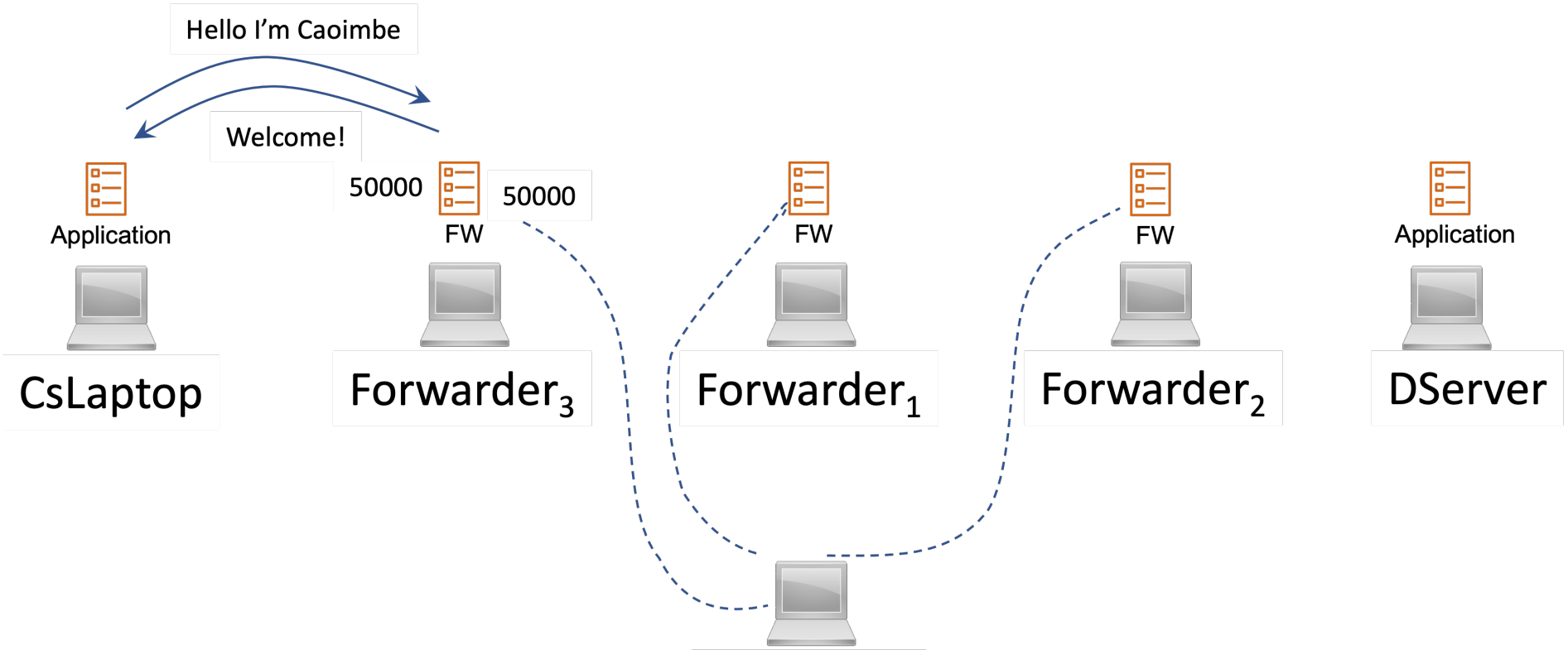
Conceptual Idea of the Overlay



DServer = Deployment Server

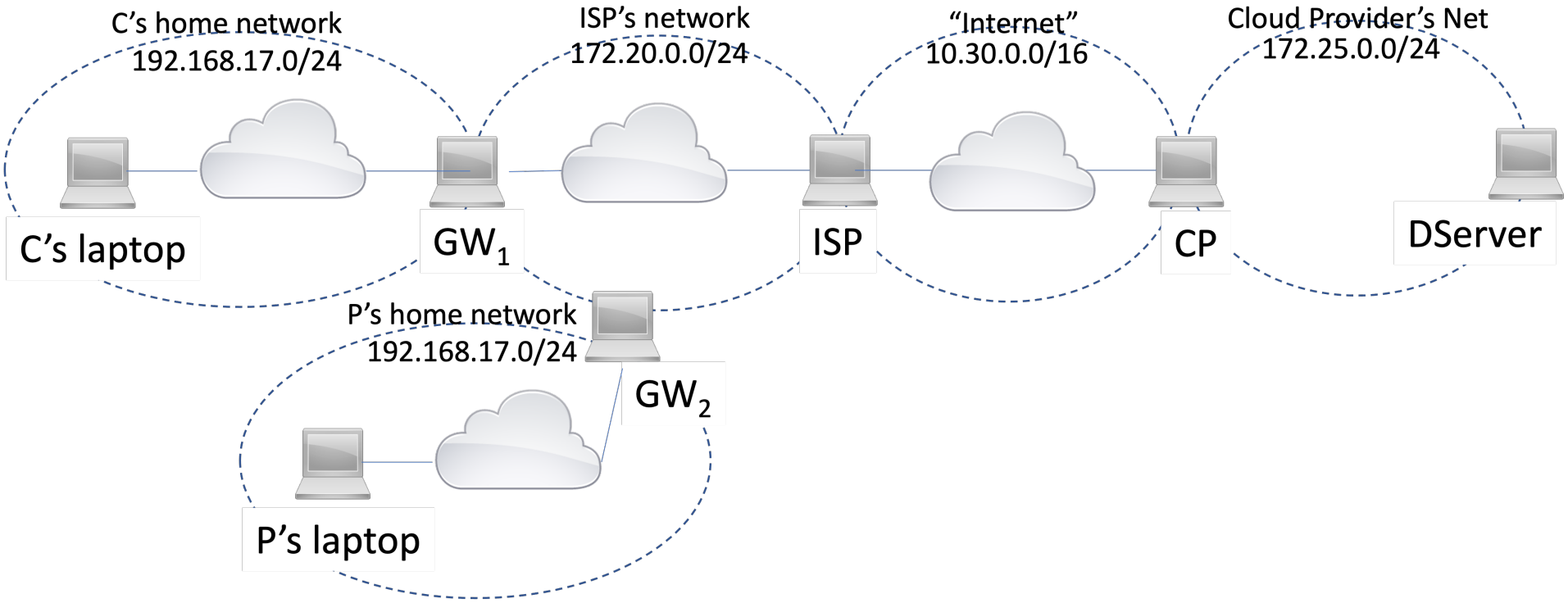
Possible Topology





Forwarder	IP address	Connections
FW1	IPaddress1	FW2, FW3
FW2	IPaddress2	DServer, FW1
FW3	IPaddress3	Caoimbe, FW1

Full Topology (just a lot of individual nets)



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