How the Internet Works

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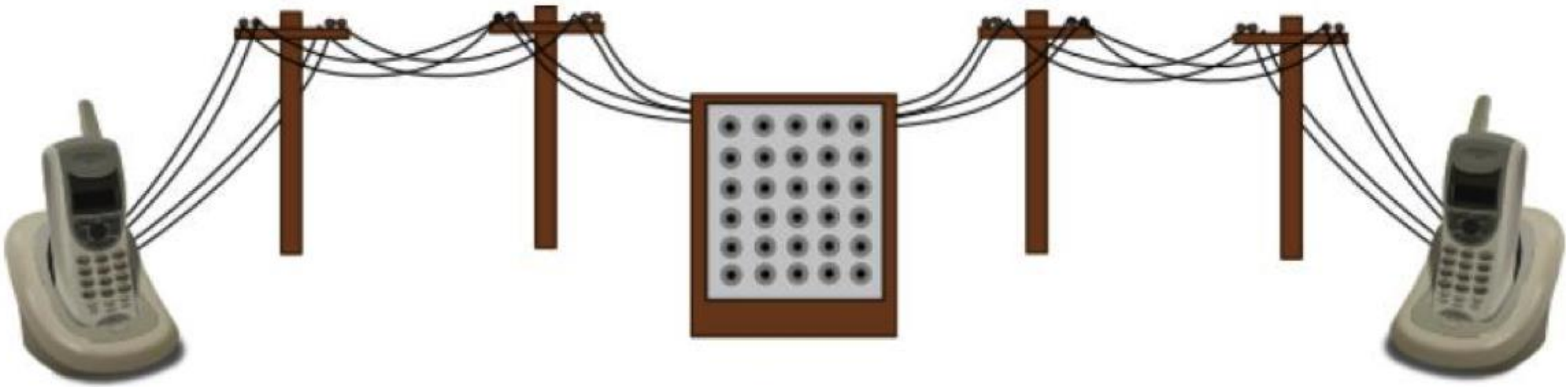
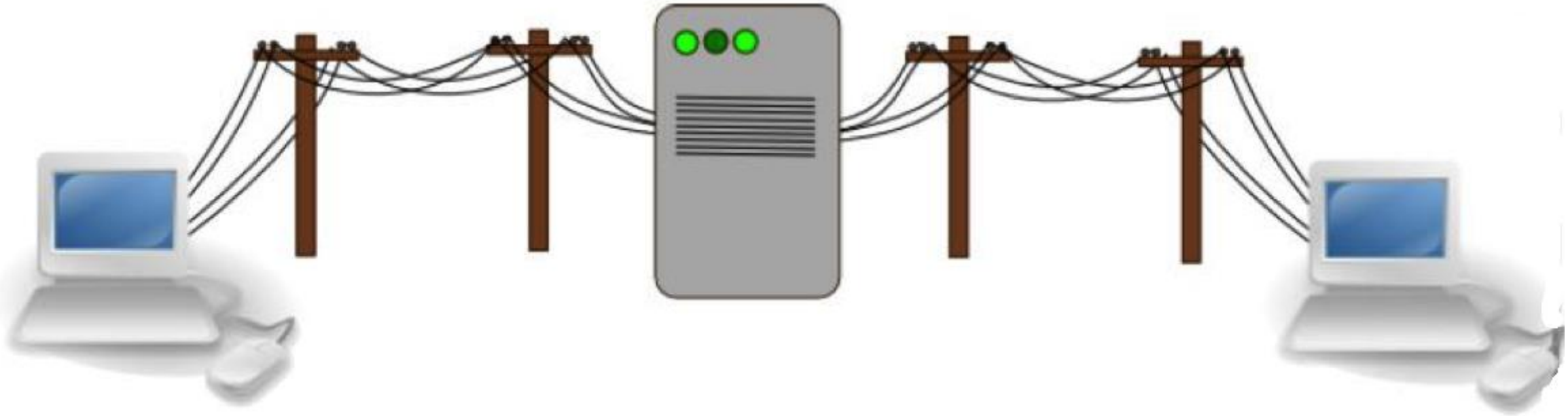
Circuit Switching

Image Source: Wikipedia





Phones vs Computers

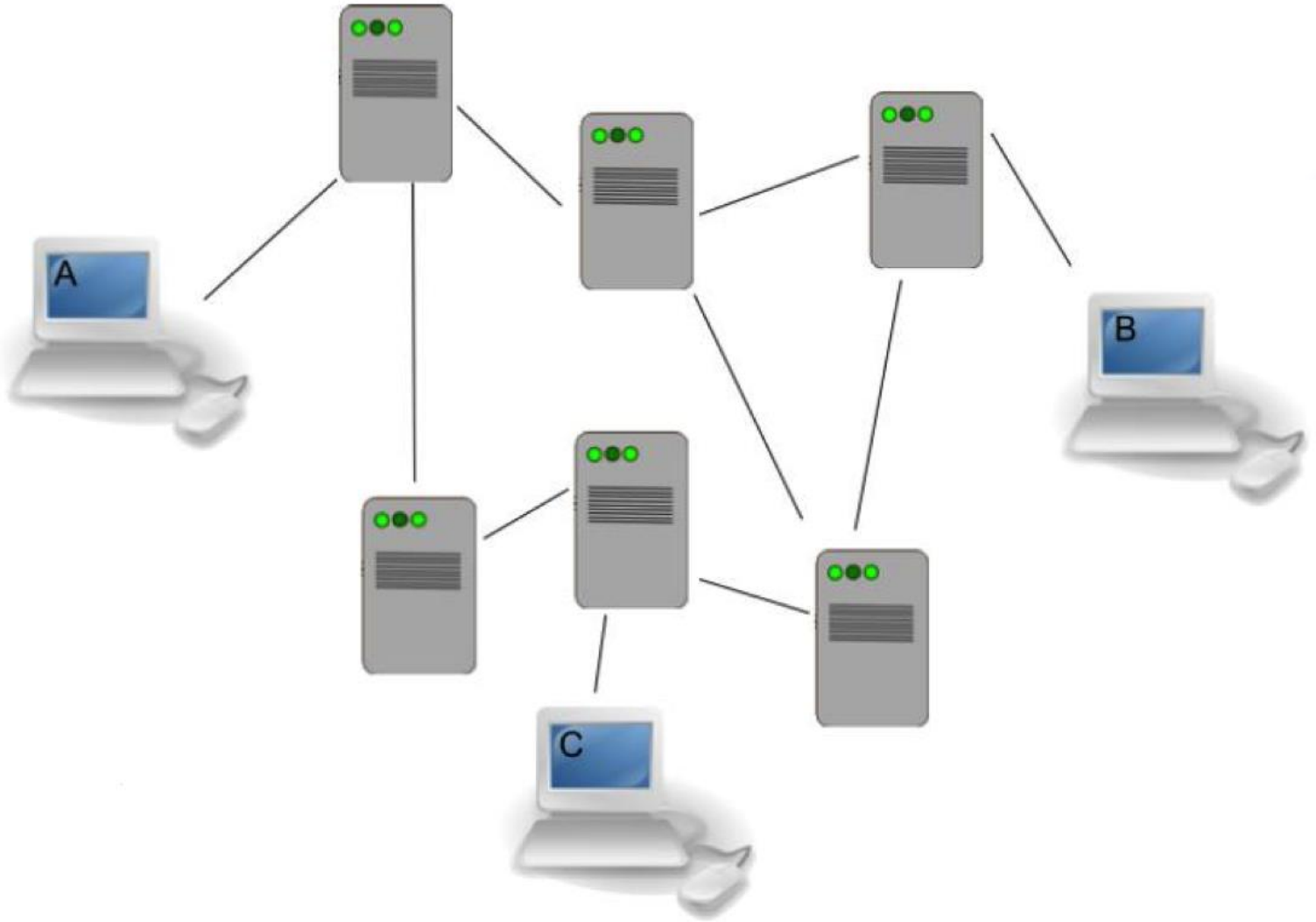
Packet Switching – Paul Baran

- RAND Corporation (Research And Development) in 1959
- Worked on what would happen in case of nuclear attack
- If networks went down, you could use low-power radios

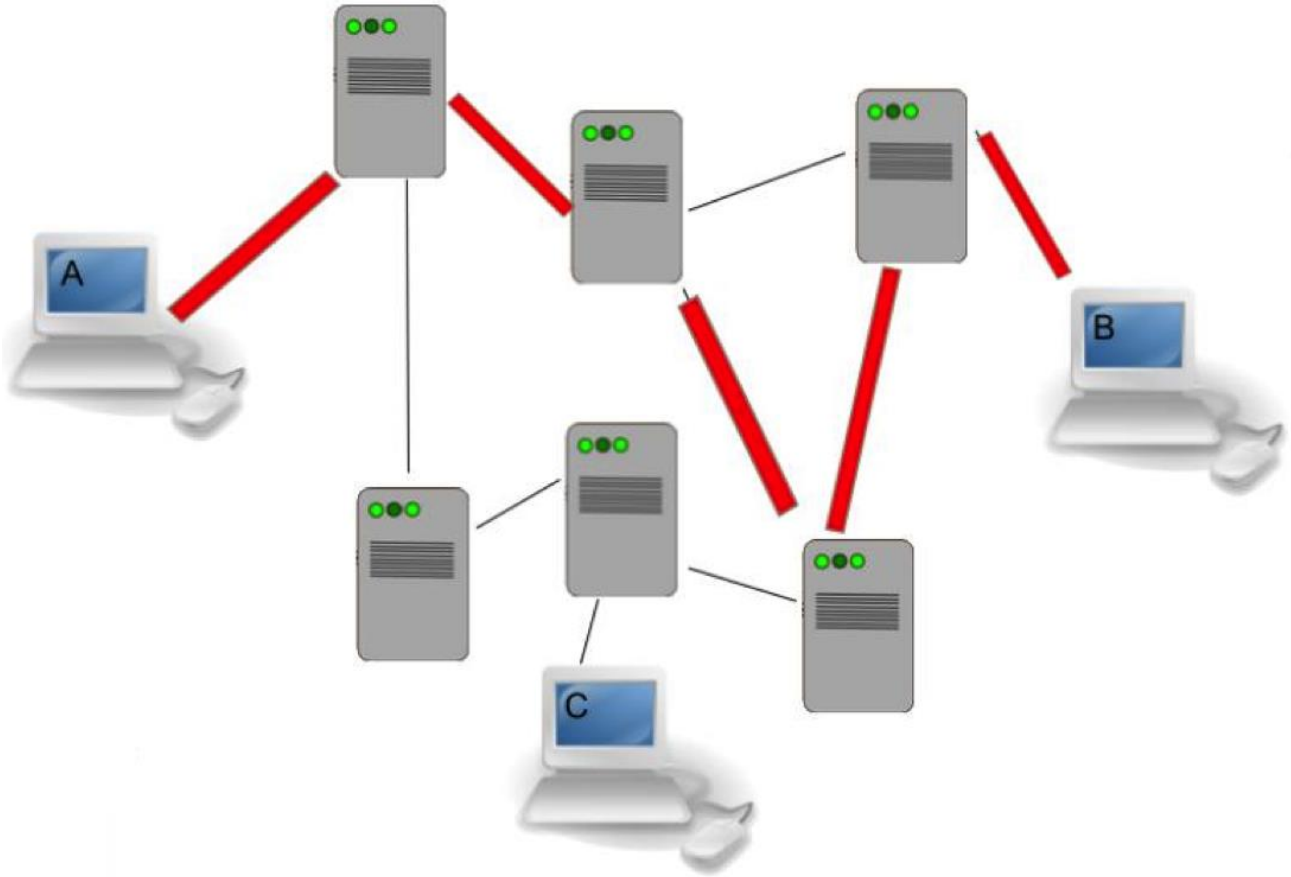
Image Source: Wikipedia

High Tech Heroes: Paul Baran

Packet Switched Network

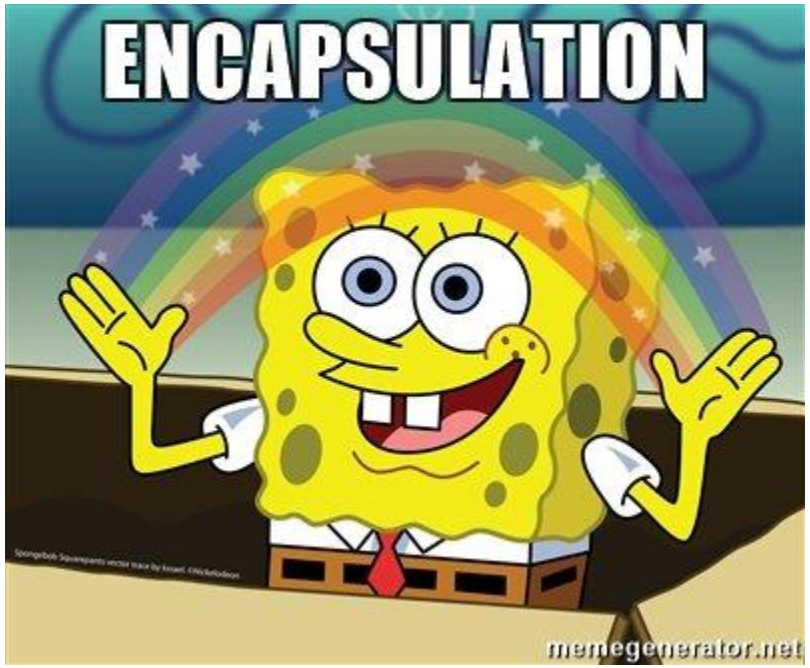


Networking



7 Layer OSI Network Model

- Application
- Presentation
- Session
- Transport - TCP/UDP
- Network - IPv4/IPv6
- Data Link - Ethernet
- Physical - 100BASE-T



Encapsulation

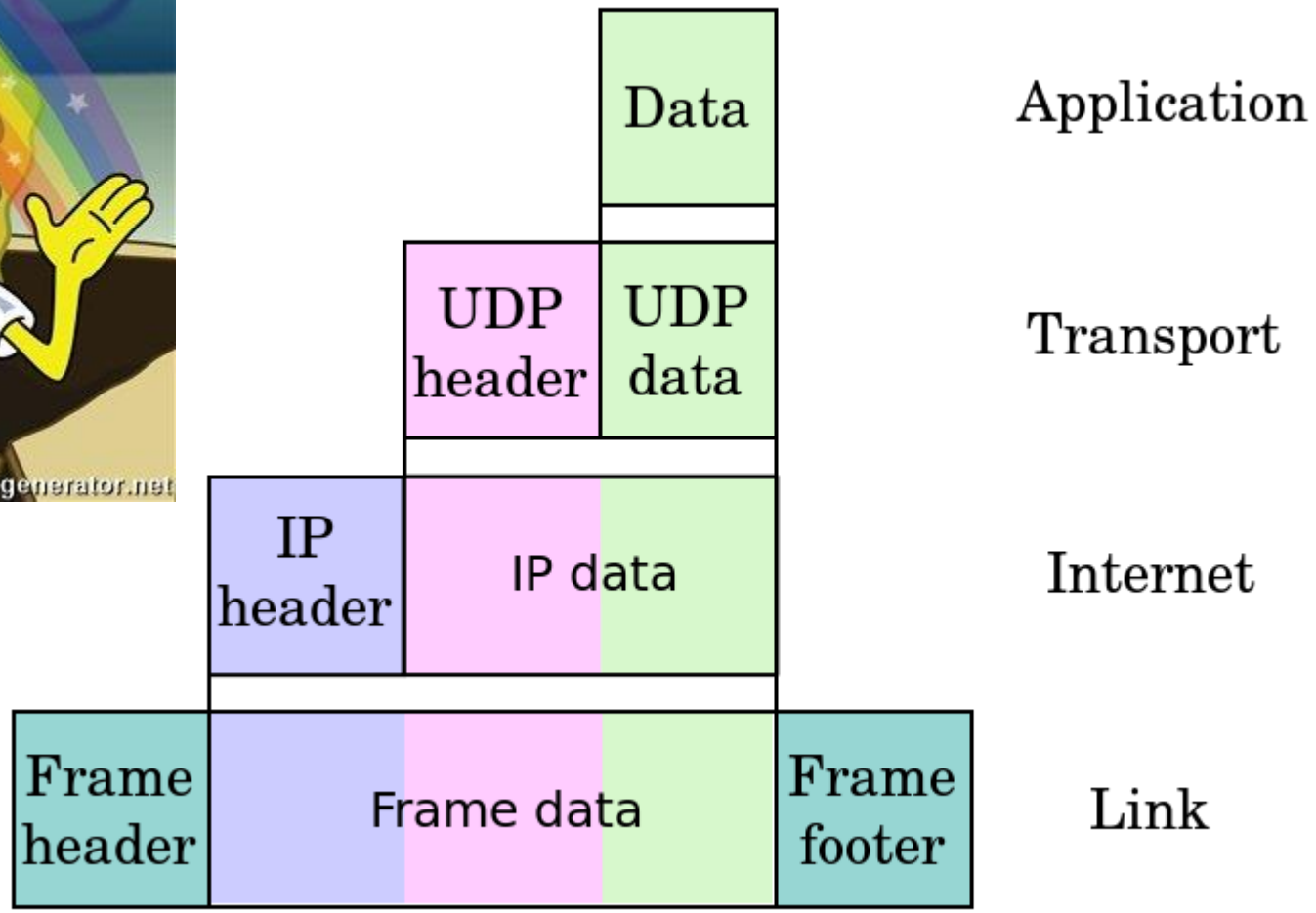


Image Source: Wikipedia

Physical Layer

- Bits and bytes layer
- 10/100/1000 BASE-T
- No knowledge of the packet, just the destination

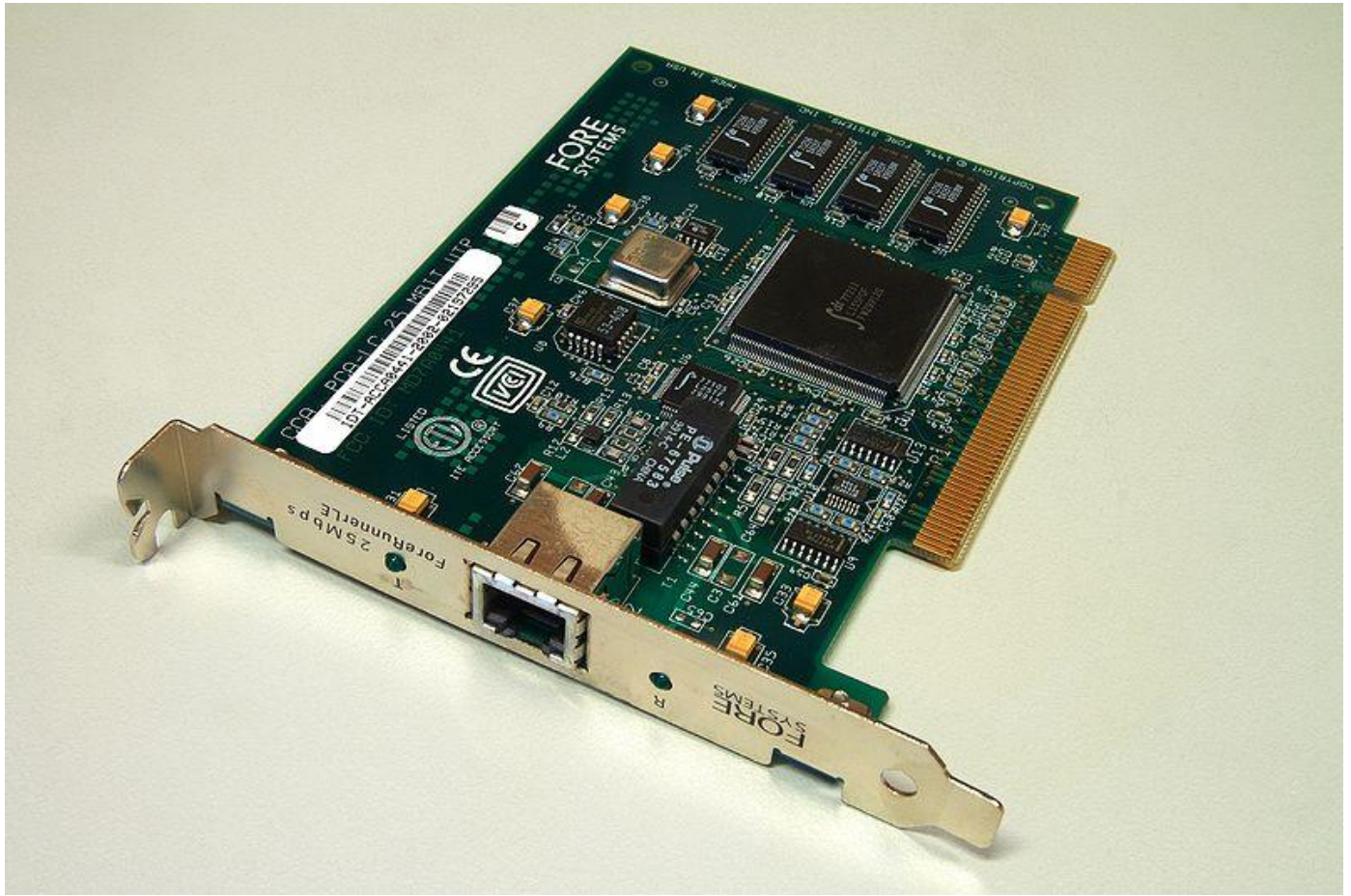
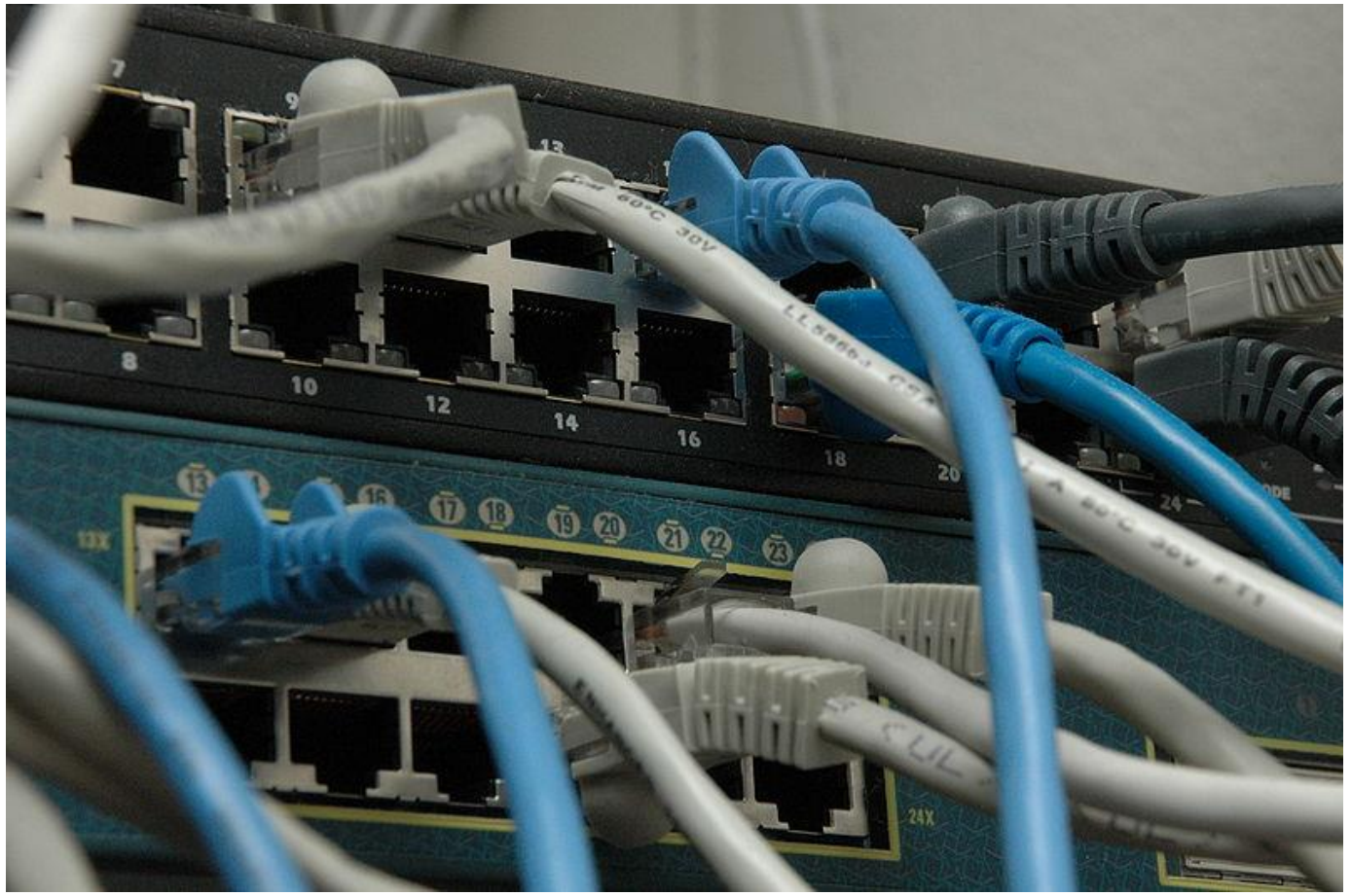


Image Source: Wikipedia

Data Link Layer

- Ethernet, frames, packets, congestion, etc.
- “Rules of the Road” for packets
  - Assures each location has an address
- Essentially the way data is routed across ethernet cables



Network Layer

IPv4 Packet Structure	
Version Info	Length
Packet ID	Flags & Offset
Protocol & TTL	Checksum
Source IP Address	
Destination IP Address	
Data...	

IPv4 vs. IPv6

- IPv4: 32 bit Addresses
  - 2^{32} = 4,294,967,296
- IPv6: 128 bit Addresses
  - 2^{128} = 340,282,366,920,938,463,463,374,607,431,768,211,456
  - Or 340 Undecillion addresses

Network Layer – IPv6

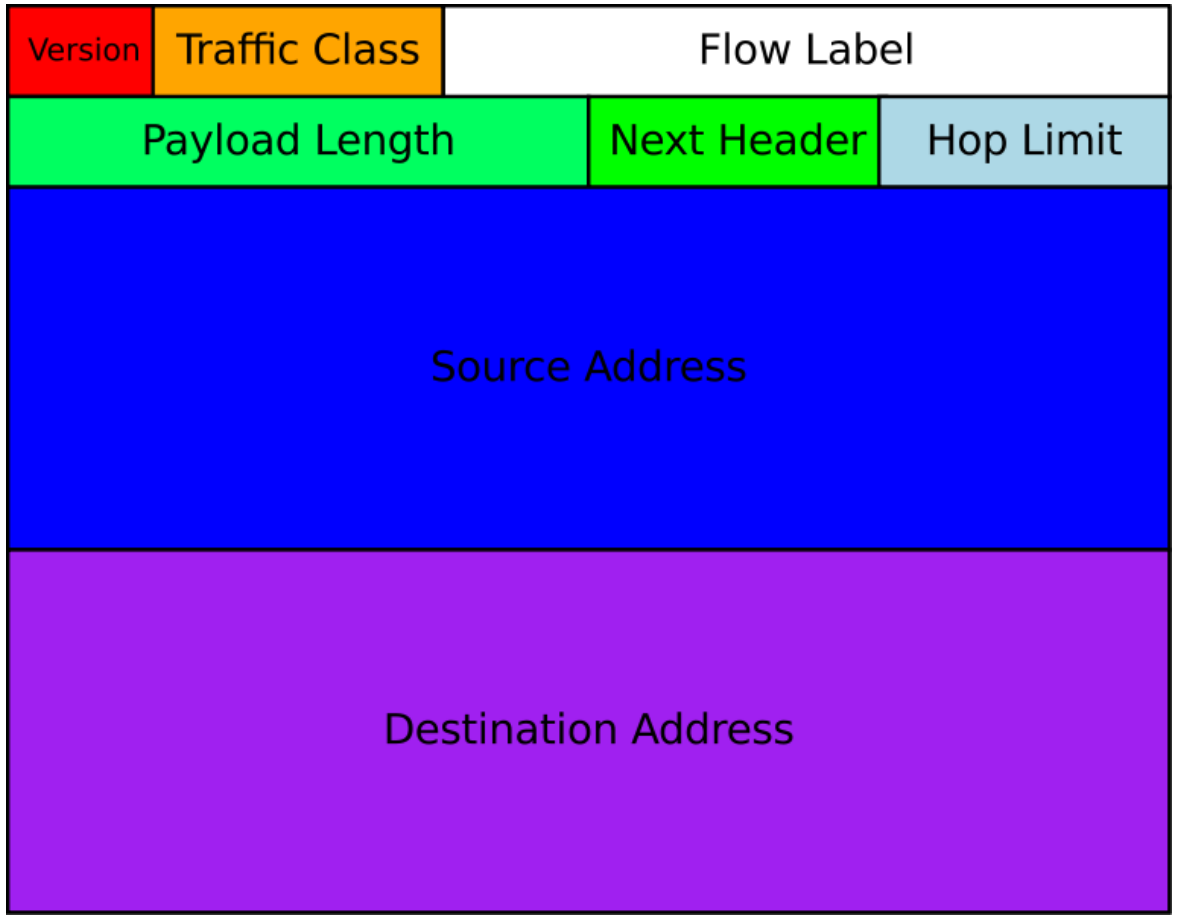


Image Source: Wikipedia

LOCAL
PUBLIC DATA NETS
HP
DEC
FORD
CSC
DDN-RVN
GENERAL ELECTRIC
XEROX
BELL LABS
APPLE
MIT
DISA
BB&N INC
BB&N INC
DoD INTEL
DISA
CABLE TV
UK MoD
MULTICAST
ARMY AISC
IBM
VPNs
DSI
DISA
SITA
MERC
CAP DEBIS CCS
NORSK
MERIT
ASIA-PACIFIC
USPS
BOEING
duPONT
DLA
HALLIBURTON
PSI
ASIA-PACIFIC
EUROPE
NORTH AMERICA
ASIA-PACIFIC
LATIN AMERICA & CARIBBEAN
US & VARIOUS
NORTH AMERICA
AFRICA
UK SOCIAL SECURITY
BB&N INC
INTEROP
ELI LILY
AFRINIC
US DEPARTMENT OF DEFENSE
ASIA-PACIFIC
NORTH AMERICA
EUROPE
EUROPE
PRUDENTIAL
BELL NORTH
HAM RADIO
JAPAN INET
EUROPE
PRIVATE (RFC 1918)
VARIOUS
GOOGLE
FLICKR
USA
DIGG
SLASHDOT
EBAY
CRAIGSLIST
ASIA-PACIFIC
LOOPBACK
JAPAN
JAPAN
LATIN AMERICA & CARIBBEAN
EUROPE (UNUSED)
ORISINAL
CANADA
VARIOUS
SONY
NORTH

Transport Layer (TCP)

TCP Packet Structure	
Source Port	Dest. Port
Sequence Number	
Acknowledgement Number	
Options	Length
Checksum	Urgent
Data...	

Transport Layer – UDP

UDP Packet Structure	
Source Port	Dest. Port
Length	Checksum
Data...	

TCP vs UDP

TCP	UDP
Connection Oriented	Connectionless
Reliable	Unreliable
Acknowledge	No Acknowledge

Application Layer

- POP/SMTP/IMAP - Email
- HTTP/FTP - World Wide Web
- DNS/DHCP - Network Setup
- SSH/RDP/Telnet - Connections

Domain Name System (DNS)

"Phonebook for the Internet"

- www.ksu.edu → 129.130.8.49
- www.google.com → 74.125.227.116
- www.ibm.com → 129.42.60.216
- www.yahoo.com → 98.138.253.109

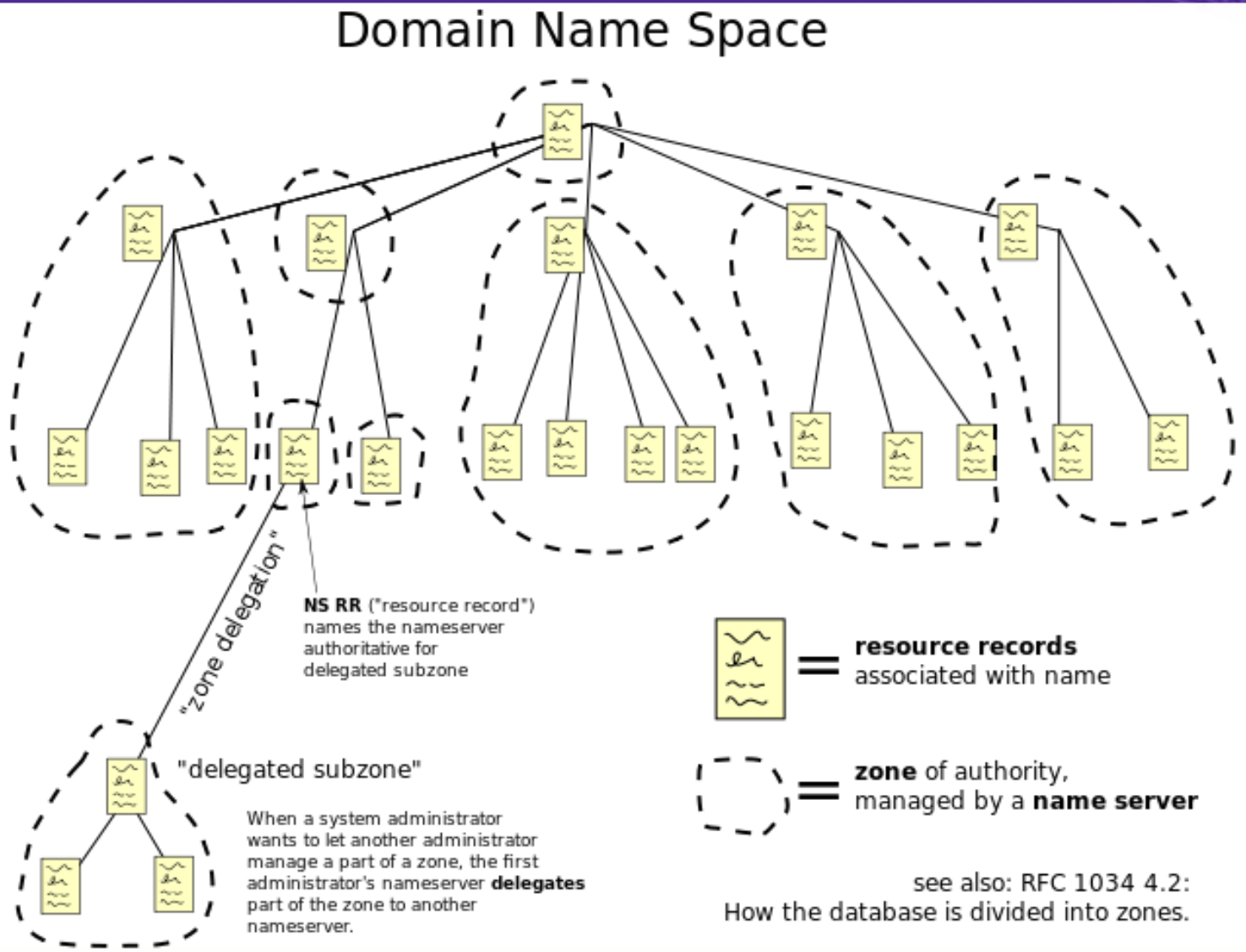


Image Source: Wikipedia

DNS Lookup

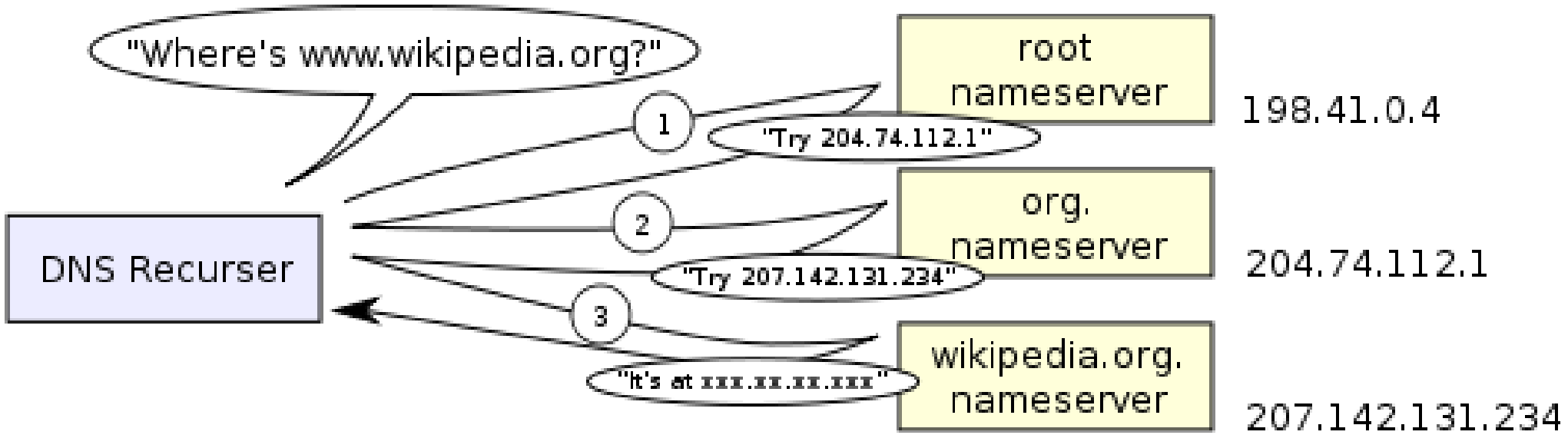


Image Source: Wikipedia

Dynamic Host Configuration Protocol (DHCP)

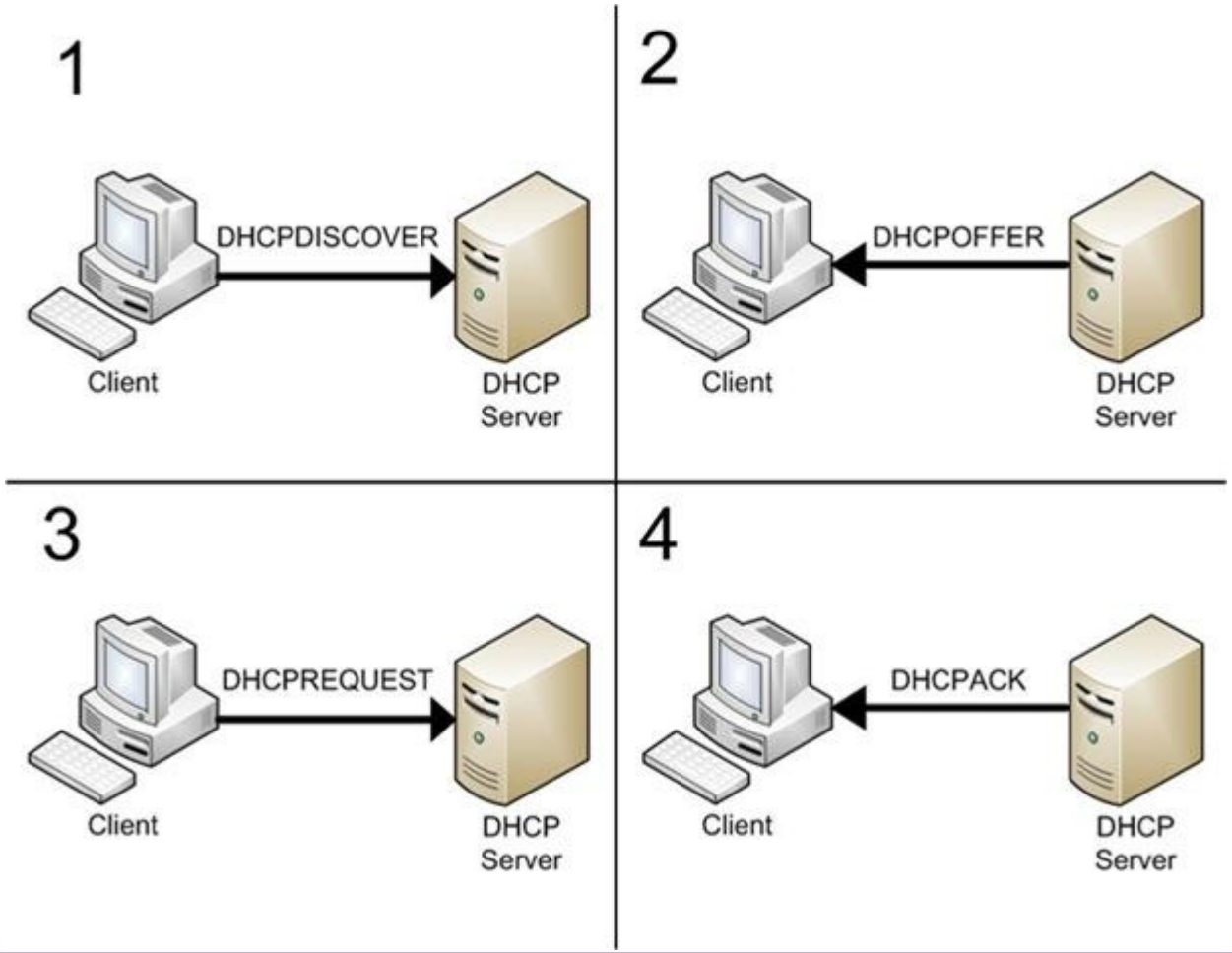


Image Source: Tech Juice

HyperText Transfer Protocol (HTTP)

- Developed by Tim Berners-Lee in the late 1980s
- Way to send and receive information through the web

Image Source: Wikipedia

```
josh@blackbox:~$ telnet en.wikipedia.org 80
Trying 208.80.152.2...
Connected to rr.pmtpa.wikimedia.org.
Escape character is '^]'.
GET /wiki/Main_Page http/1.1
Host: en.wikipedia.org
```

Request

```
HTTP/1.0 200 OK
Date: Thu, 03 Jul 2008 11:12:06 GMT
Server: Apache
X-Powered-By: PHP/5.2.5
Cache-Control: private, s-maxage=0, max-age=0, must-revalidate
Content-Language: en
Vary: Accept-Encoding,Cookie
X-Vary-Options: Accept-Encoding;list-contains=gzip,Cookie;string-contains=enwikiToken;string-contains=enwikiLoggedOut;string-contains=enwiki_session;
string-contains=centralauth_Token;string-contains=centralauth_Session;string-contains=centralauth_LoggedOut
Last-Modified: Thu, 03 Jul 2008 10:44:34 GMT
Content-Length: 54218
Content-Type: text/html; charset=utf-8
X-Cache: HIT from sq39.wikimedia.org
X-Cache-Lookup: HIT from sq39.wikimedia.org:3128
Age: 3
X-Cache: HIT from sq38.wikimedia.org
X-Cache-Lookup: HIT from sq38.wikimedia.org:80
Via: 1.0 sq39.wikimedia.org:3128 (squid/2.6.STABLE18), 1.0 sq38.wikimedia.org:80 (squid/2.6.STABLE18)
Connection: close
```

Response headers

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en" lang="en" dir="ltr">
        <head>
                <meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
                        <meta name="keywords" content="Main Page,1778,1844,1863,1938,1980 Summer Olympics,2008,2008 Guizhou riot,2008 Jerusal
...
''' This content has been removed to save space
...
"Non-profit organization">nonprofit</a> <a href="http://en.wikipedia.org/wiki/Charitable_organization" title="Charitable organization">charity</a>.<b
r /></li>
                        <li id="privacy"><a href="http://wikimediafoundation.org/wiki/Privacy_policy" title="wikimedia:Privacy policy">Privac
y policy</a></li>
                        <li id="about"><a href="/wiki/Wikipedia:About" title="Wikipedia:About">About Wikipedia</a></li>
                        <li id="disclaimer"><a href="/wiki/Wikipedia:General_disclaimer" title="Wikipedia:General disclaimer">Disclaimers</a>
</li>
                </ul>
        </div>
</div>

        <script type="text/javascript">if (window.runOnloadHook) runOnloadHook();</script>
<!-- Served by srv93 in 0.050 secs. --></body></html>
Connection closed by foreign host.
josh@blackbox:~$
```

Response body

Image Source: [Wikipedia]

HTTP Commands

- GET
- POST
- HEAD
- PUT
- DELETE

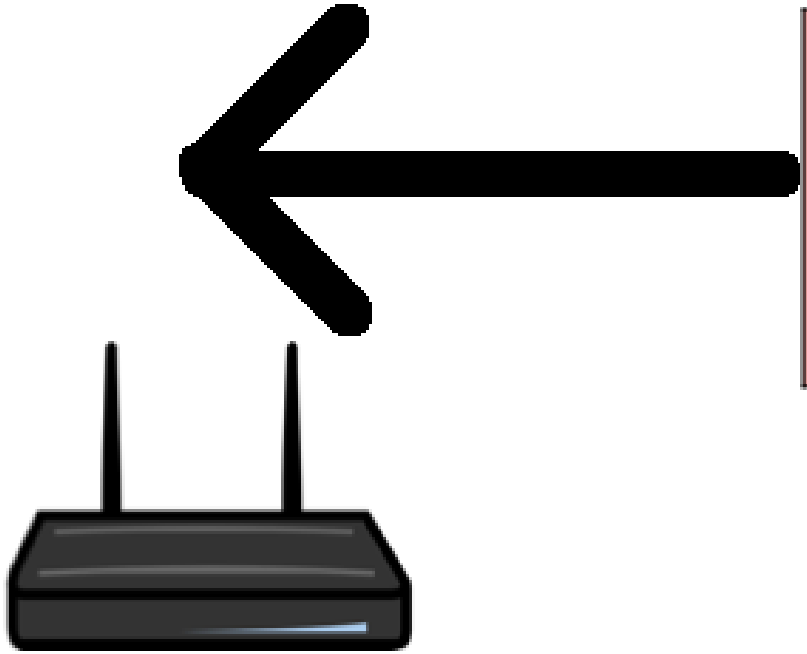
HTTP Status Codes

- 200 – OK
- 301 – Moved Permanently
- 403 – Forbidden
- 404 – Not Found
- 500 – Internal Server Error
- 503 – Service Unavailable

Packet Switching Activity

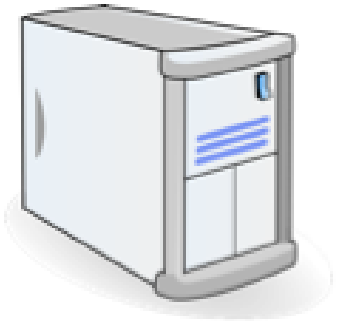
- Each server has a secret number
- Try to guess each server's secret number by playing the "Higher/Lower" game over HTTP
- Server with the most correct numbers when time runs out wins!

DHCP Request



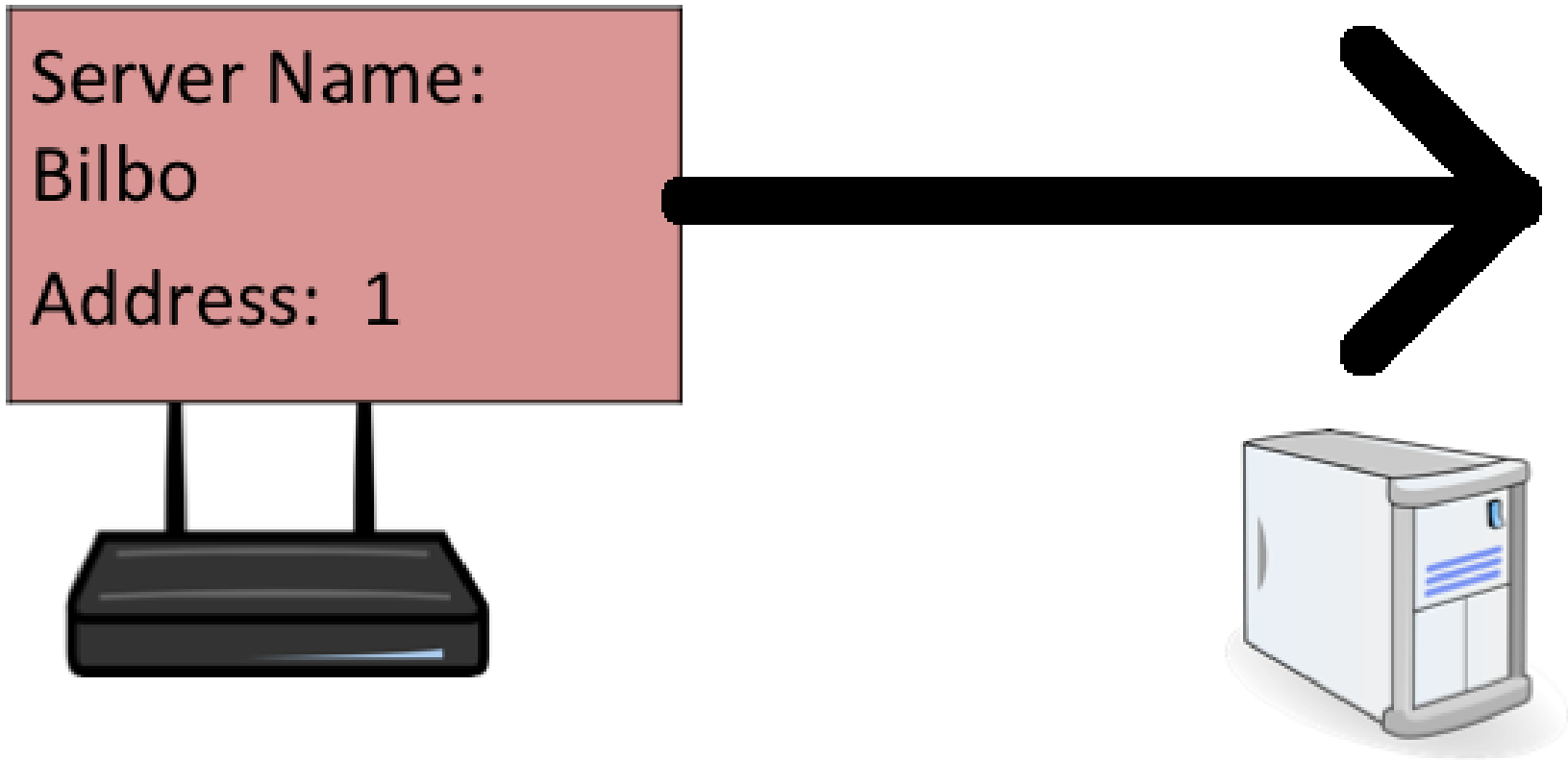
Server Name:
Bilbo

Address:

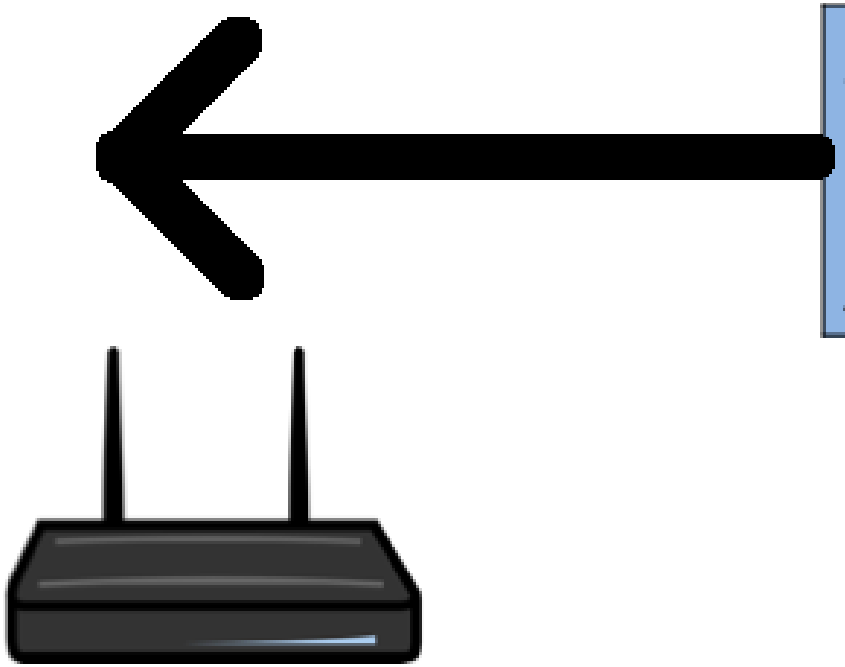


My Name is Bilbo!
I need an address

DHCP Response



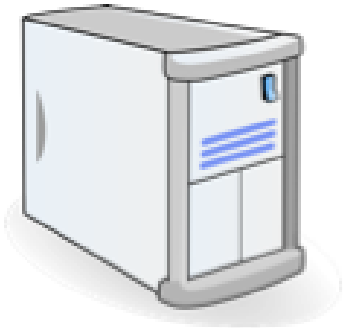
DNS Lookup



Source: 1

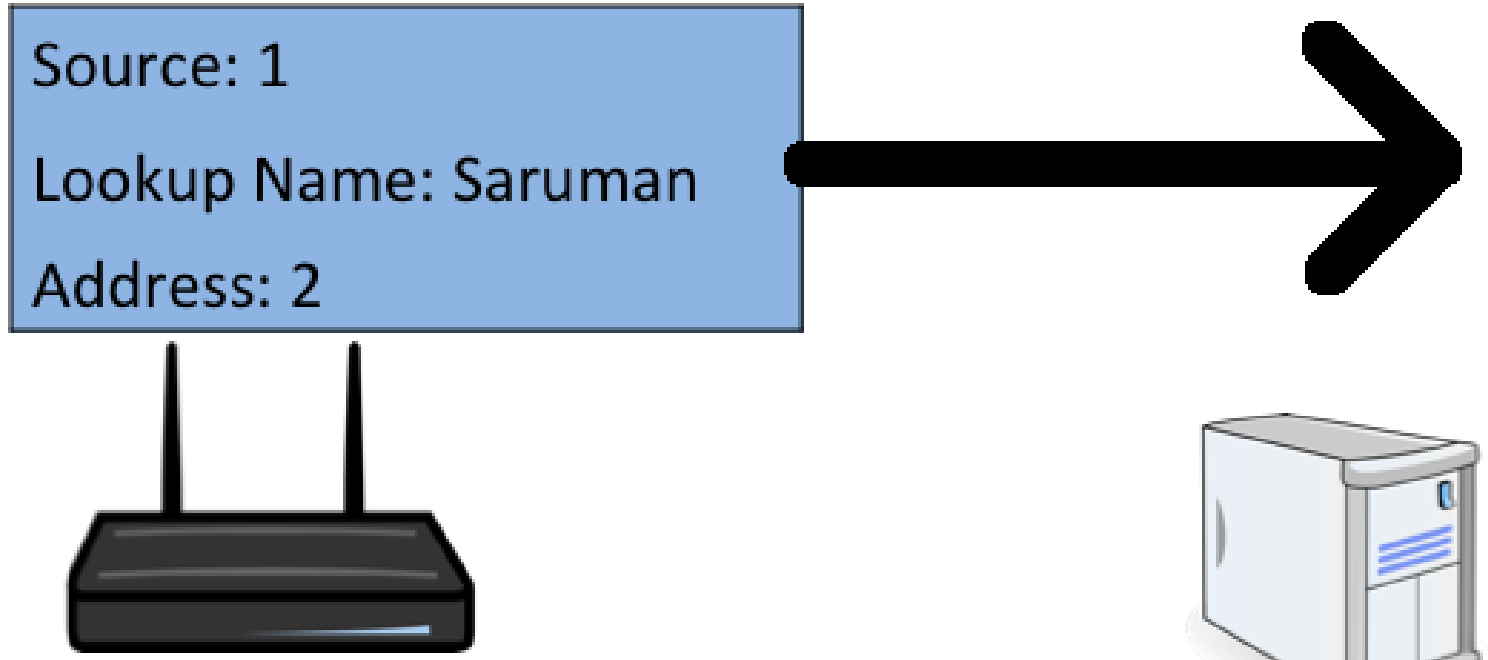
Lookup Name: Saruman

Address:

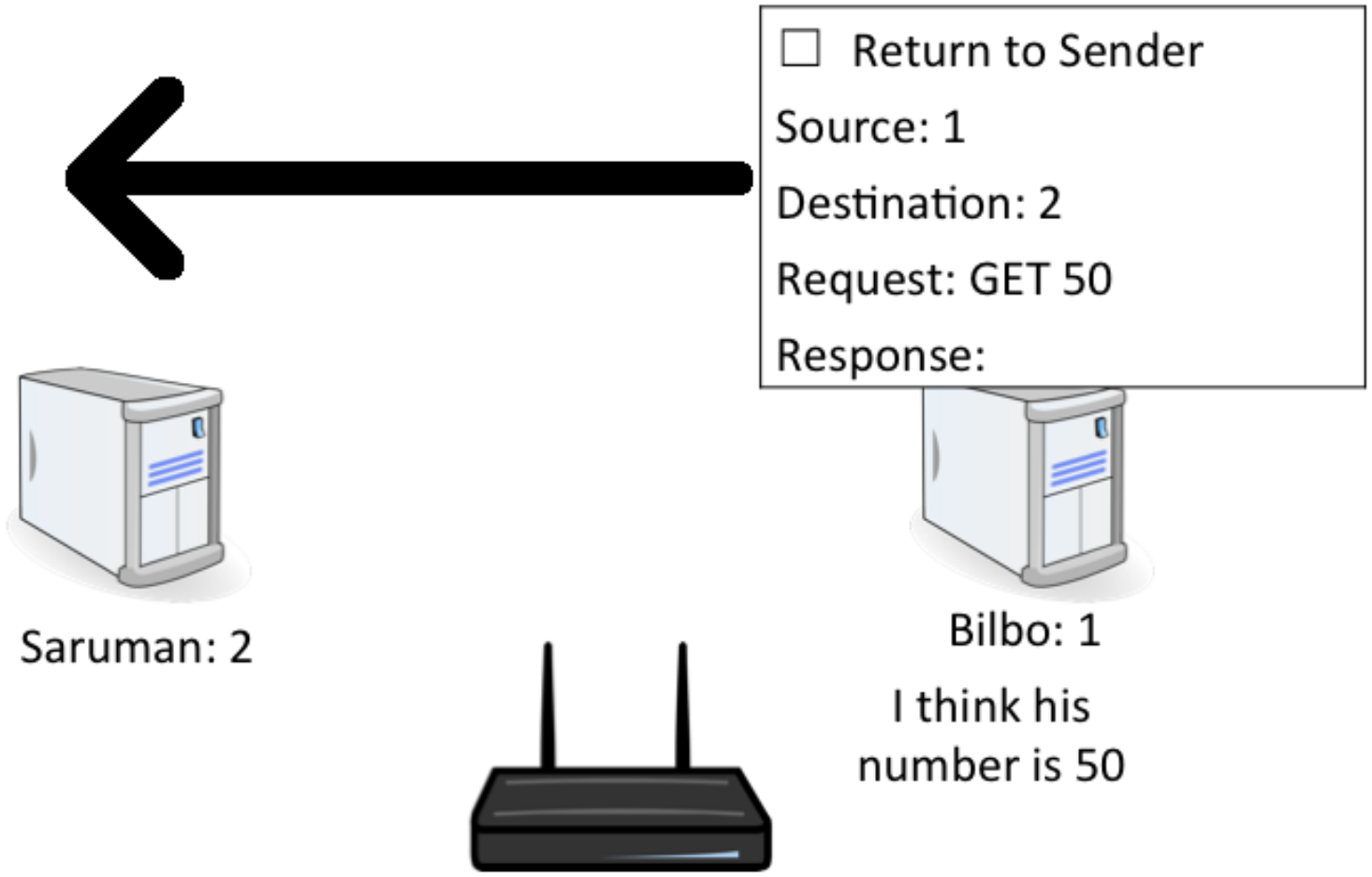
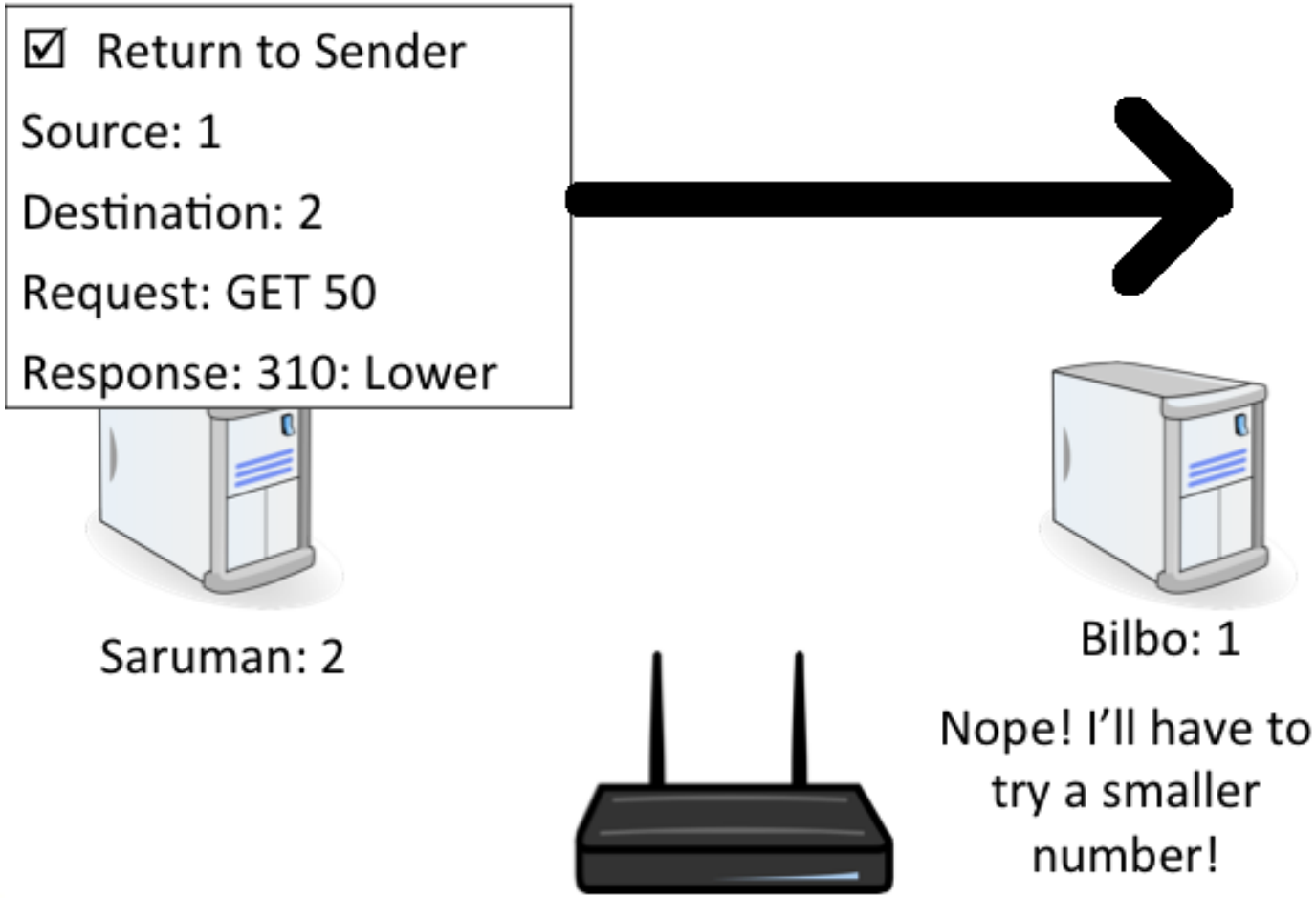


I'd like to talk to Saruman.

DNS Response



HTTP Request



HTTP Response