

Internet

# How The Internet Works Part II

[www.quartomese.com](http://www.quartomese.com)

Thomas Aprille, Phd

Internet

Internet

Internet



You

Internet

# What You Want To Do

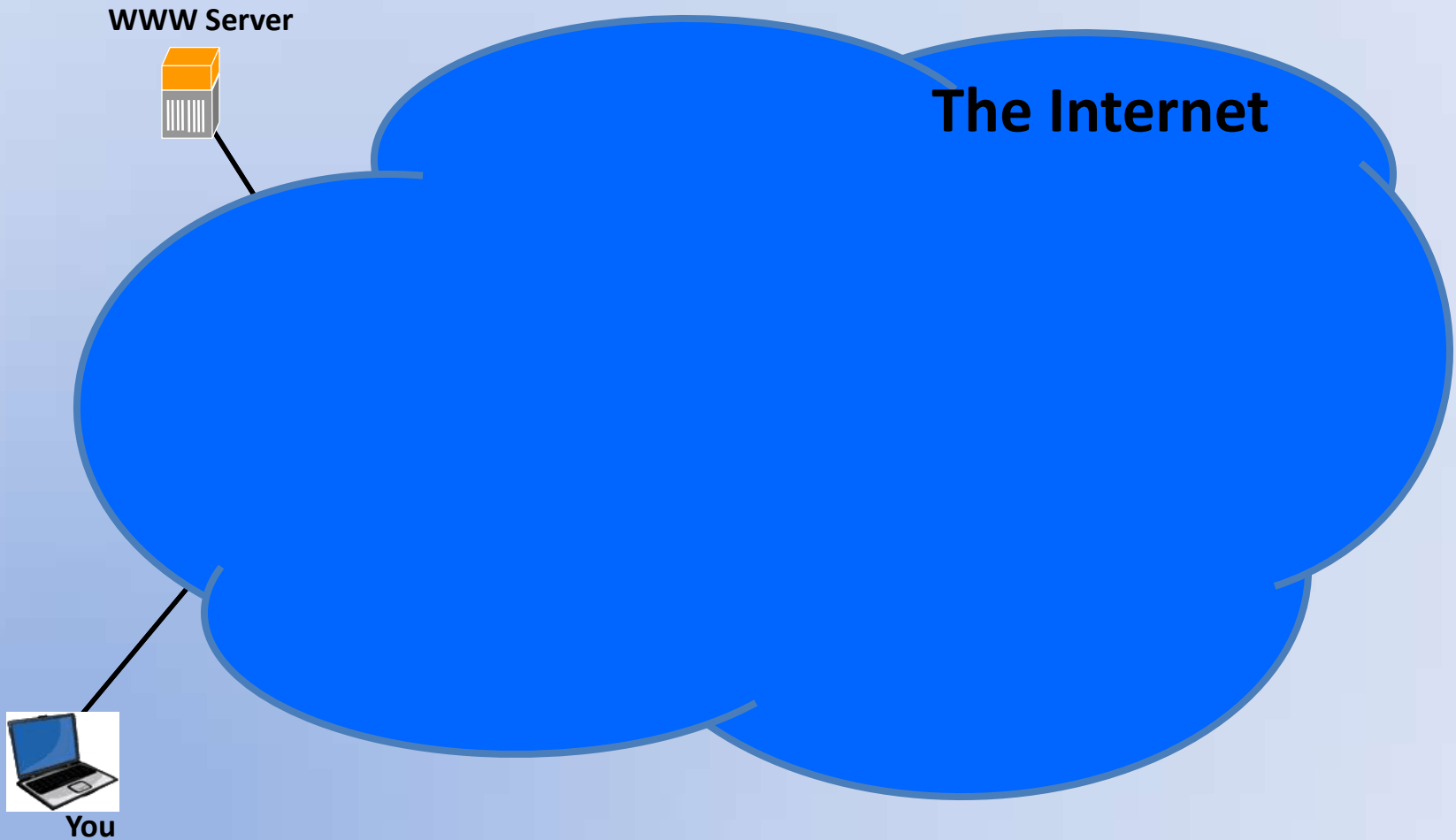
- WEB page access
  - Buy something
  - Watch Movie
  - Pay bill
  - ... etc
- Use App
  - Buy something
  - Watch Movie
  - Pay bill
  - ... etc

# What You Want To Do

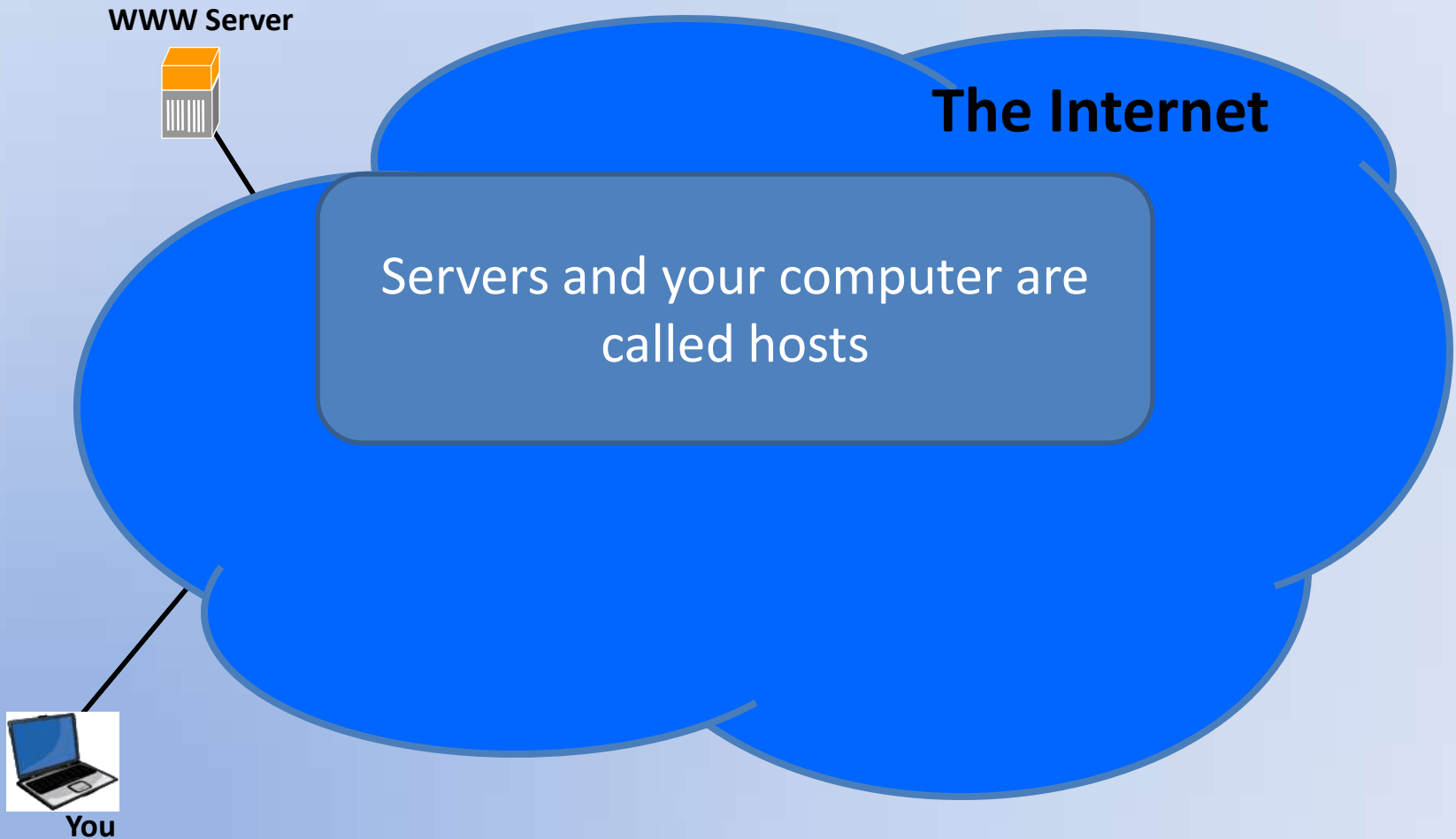
- WEB page access
  - Buy something
  - Watch Movie
  - Pay bill
  - ... etc
- Use App
  - Buy something
  - Watch Movie
  - Pay bill
  - ... etc

WEB pages use URLs,  
e.g., <http://quartomese.com>

# Get WEB Page



# Get WEB Page



# Get WEB Page



# Get WEB Page



# quarTomese



[Home](#) [Pictures](#) [Telephone Quiz](#) [Roman Arch](#) [Roman Empire](#)

Calculators: [Interest](#) [Metric](#) [Sudoku](#)



## Pictures

### **United States**

**Arizona:** Grand Canyon,  
Sedona Area, Phoenix Area (Apache Trail, Phoenix's Papago Park), Tucson (Catalina State Park, Mission San Xavier Del Bac, Sabino Canyon, Saguaro National Park - East)

**California:** Death Valley NP, Escondido (Safari Park), Escondido Area Missions, Golden Gate NRA, Joshua Tree NP, Mojave National

**Massachusetts:** Boston, Boston Harbor Islands (Castle Island, Deer Island, George's Island, Little Brewster Island - Boston Light, Peddock's Island, Spectacle Island), Sutton - Purgatory Chasm

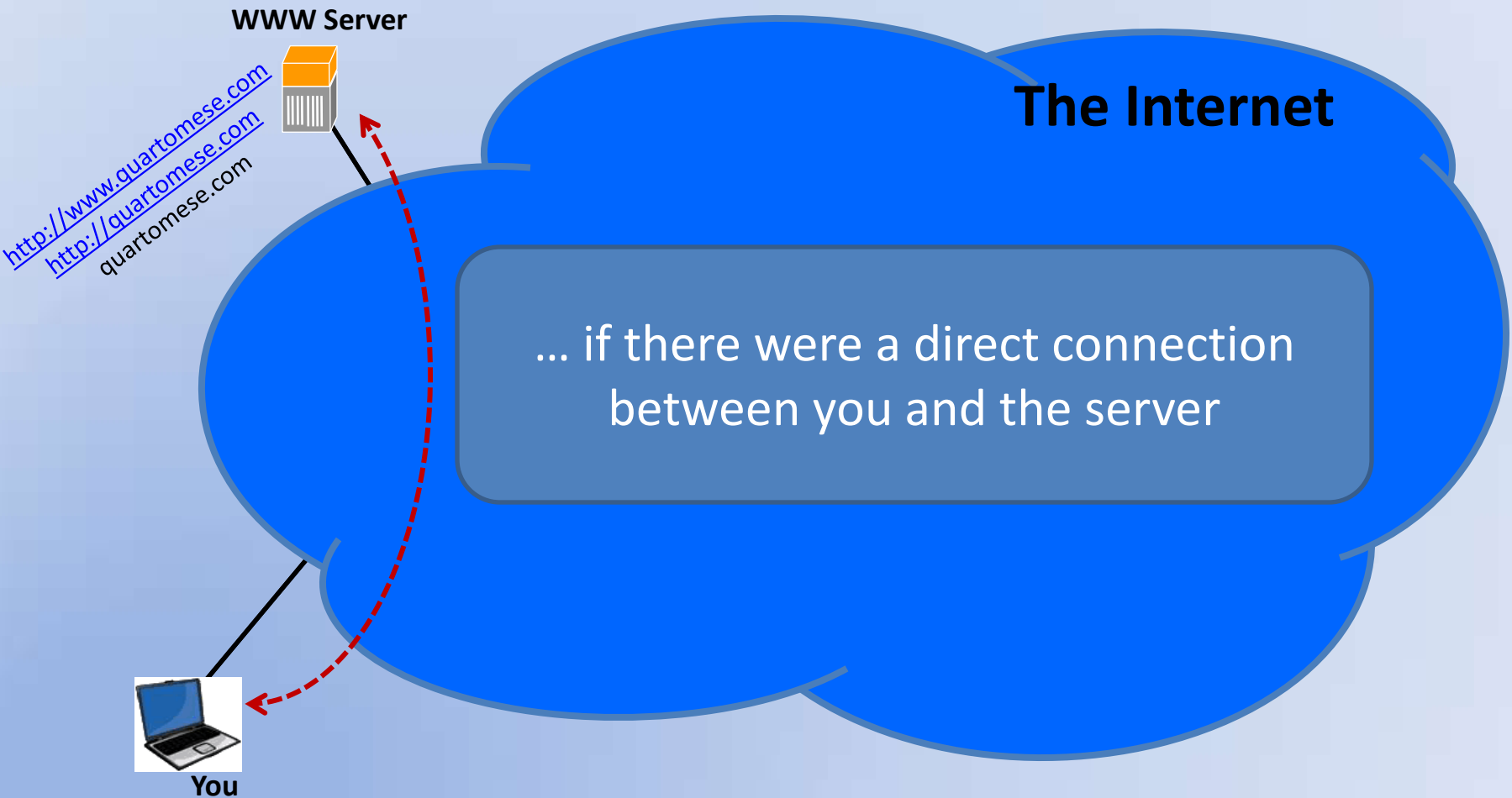
**Montana:** Big Sky, Glacier House

Internet

ht+



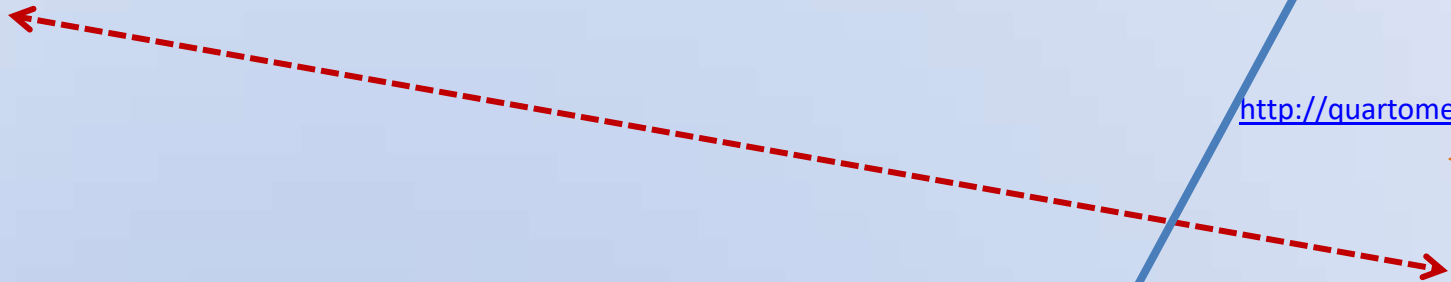
# Get WEB Page



# NAME SERVER – CONNECT – SSL/TLS - HTTP



You



<http://quartomese.com/index.htm>

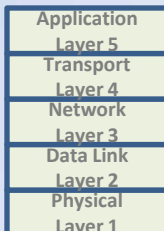
WWW Server



```

GET /index.htm http/1.1
Host: quartomese.com
User-Agent: ... Firefox/51.0
Connection: Keep-Alive
Accept-Language: en-US
Cookie: roundcube=enabled
HTTP/1.1 200 OK
Keep-Alive: timeout=15, max=100
...
Content-Type: text/html
(The index page)

```



HTTP = Hyper Text Transport Protocol

index.htm, default.htm, index.html, default.html are all default pages

[http://www.eventhelix.com/RealtimeMantra/Networking/http\\_sequence\\_diagram.pdf](http://www.eventhelix.com/RealtimeMantra/Networking/http_sequence_diagram.pdf)

[https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP\\_Basics.html](https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_Basics.html)

<http://quartomese.com/index.htm>



# NAME SERVER – CONNECT – SSL/TLS - HTTP

You

```

<body style="background-color: #cccccc;
<!--
<div align="center">
  <table border="1" width="100%" cellpadding="1" cellspacing="1" height="100">
    <tr>
      <td align="center" colspan="2">
        <img alt="Logo" />
      </td>
    </tr>
  </table>
</div>
</body>
</html>

```

<http://quartomese.com/index.htm>

WWW Server



```

GET /index.htm http/1.1
Host: quartomese.com
User-Agent: ... Firefox/51.0
Connection: Keep-Alive
Accept-Language: en-US
Cookie: roundcube=enabled
HTTP/1.1 200 OK
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[https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP\\_Basics.html](https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_Basics.html)

# NAME SERVER – CONNECT – SSL/TLS - HTTP



You

```
body style="background-color: #cccccc;
margin: 0px; padding: 0px;
...
table border="1" width="100%" cellpadding="1" cellspacing="1" height="100%">
|  |
| --- |
|  |


...

```

<http://quartomese.com/index.htm>

WWW Server



→

```
GET /index.htm http/1.1
Host: quartomese.com
User-Agent: ... Firefox/51.0
Connection: Keep-Alive
Accept-Language: en-US
Cookie: roundcube=enabled
```

←

```
HTTP/1.1 200 OK
Keep-Alive: timeout=15, max=100
...
Content-Type: text/html
(The index page)
```



index.htm, default.htm, index.html, default.html are all default pages

# NAME SERVER – CONNECT – SSL/TLS - HTTP



## quarTomese



- [Home](#) [Pictures](#) [Telephone Quiz](#) [Roman Arch](#) [Roman Empire](#)
- Calculators: [Interest](#) [Metric](#) [Sudoku](#)



Pictures

### United States

**Arizona:** [Grand Canyon](#),  
[Sedona Area](#), [Phoenix Area \(Apache Trail, Phoenix's Papago Park\)](#), [Tucson \(Catalina State Park, Mission San Xavier Del Bac, Sabino Canyon, Saguaro National Park - East\)](#)

**California:** [Death Valley NP](#), [Escondido \(Safari Park\)](#), [Escondido Area Missions](#), [Golden Gate NRA](#), [Joshua Tree NP](#), [Mojave National](#)

**Massachusetts:** [Boston](#), [Boston Harbor Islands \(Castle Island, Deer Island, George's Island, Little Brewster Island - Boston Light, Peddock's Island, Spectacle Island\)](#), [Sutton - Purgatory Chasm](#)

<http://quartomese.com/index.htm>

WWW Server



1.1  
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/51.0  
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-US  
nabled  
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<http://quartomese.com>

# NAME SERVER - CONNECT - SSL/TLS - HTTP



```
tbody style="background-color: #cccccc;">
<!--
Copyright 2002, quartomese.com
-->
<div align="center">
  <table border="1" width="70%" cellpadding="3" cellspacing="3" height="70%">
    <tr>
      <td align="center">
        
      </td>
      <td align="center">
        <div style="text-align: center; font-size: 24px; font-weight: bold; margin-bottom: 10px;>quarTomese</div>
        <table border="0" style="width: 100%; text-align: center;>
          <tr>
            <td align="center" style="padding: 2px 10px;><a href="/">Home</a>
            <td align="center" style="padding: 2px 10px;><a href="/pictures">Pictures</a>
            <td align="center" style="padding: 2px 10px;><a href="/telephone">Telephone Quiz</a>
            <td align="center" style="padding: 2px 10px;><a href="/roman">Roman Arch</a>
            <td align="center" style="padding: 2px 10px;><a href="/roman">Roman Empire</a>
          </tr>
        </table>
        <div style="text-align: center; margin-top: 10px;>
          Calculators: <a href="/interest">Interest</a> <a href="/metric">Metric</a> <a href="/sudoku">Sudoku</a>
        </div>
      </td>
    </tr>
  </table>
</div>
```

<http://quartomese.com>

WWW Server



GET / http/1.1  
Host: quartomese.com  
User-Agent: ... Firefox/51.0  
Connection: Keep-Alive  
Accept-Language: en-US  
Cookie: roundcube=enabled

HTTP/1.1 200 OK  
Keep-Alive: timeout=15, max=100  
...  
Content-Type: text/html  
(The index page)

**quarTomese**

[Home](#) [Pictures](#) [Telephone Quiz](#) [Roman Arch](#) [Roman Empire](#)

Calculators: [Interest](#) [Metric](#) [Sudoku](#)

**United States**

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[https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP\\_Basics.html](https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_Basics.html)



# URL

- <http://www.quartomese.com>
  - <http://www.quartomese.com/index.htm>
  - [www.quartomese.com/index.htm](http://www.quartomese.com/index.htm)
  - [quartomese.com/index.htm](http://www.quartomese.com/index.htm)
  - [quartomese.com](http://www.quartomese.com)

# URL

- URL (Uniform Resource Locator)
  - <http://quartomese.com/Pix/CA/monoLake.php>
    - Protocol identifier: http, https, ftp
    - Domain name: quartomese.com
      - or www.quartomese.com
    - Resource name: /Pix/CA/monoLake.php





WWW Server

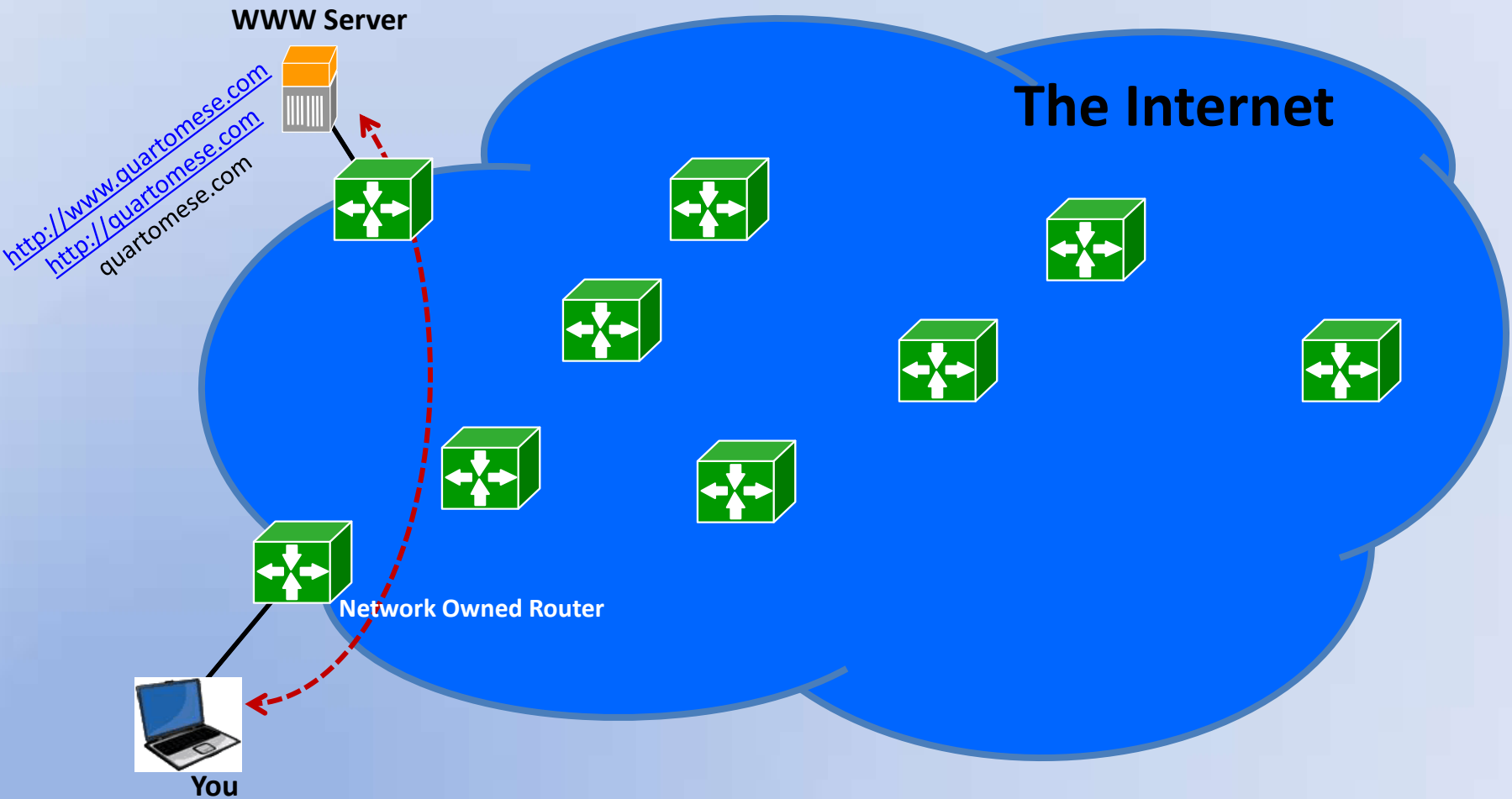


# Routing the IP packet

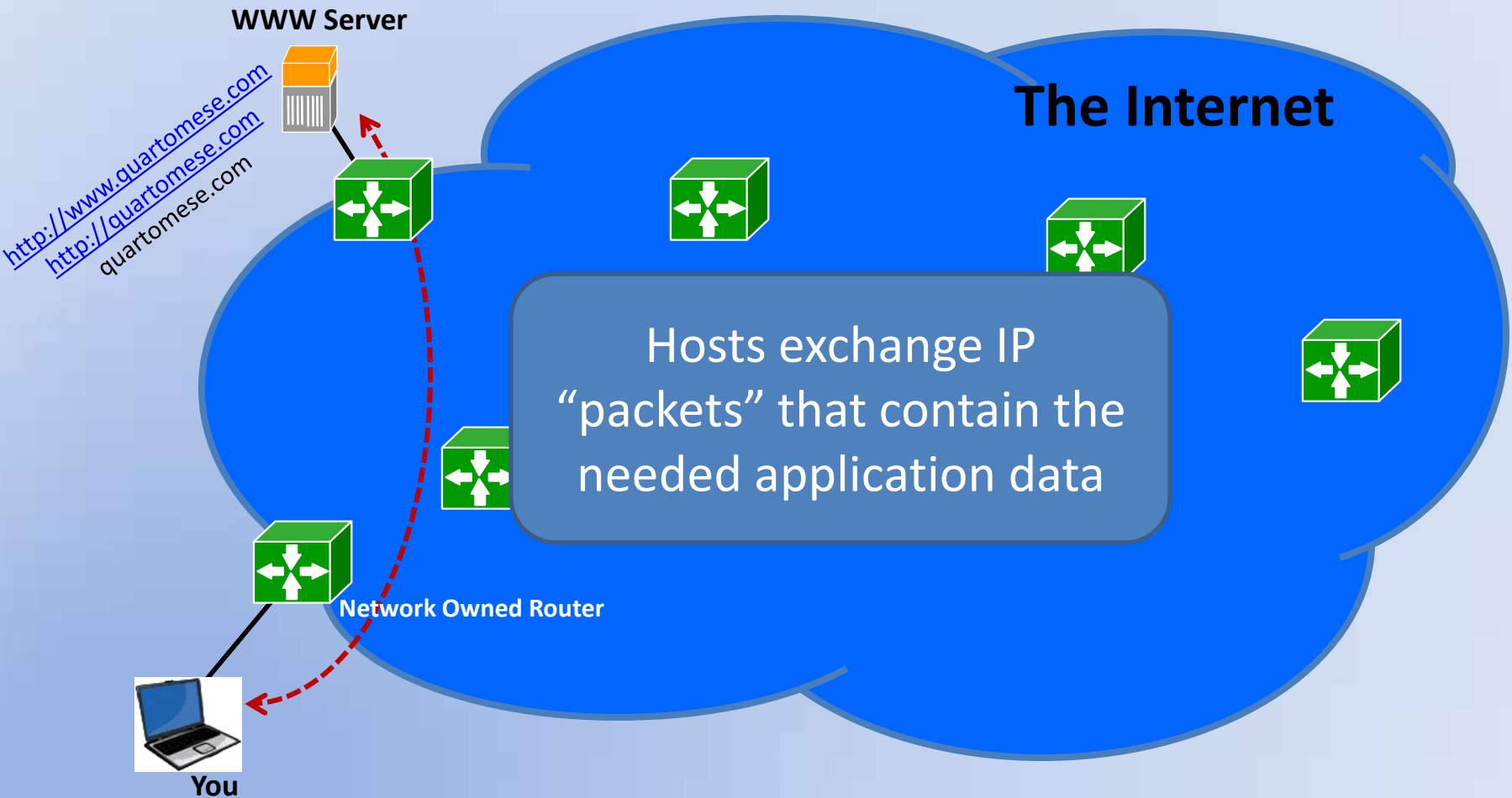


You

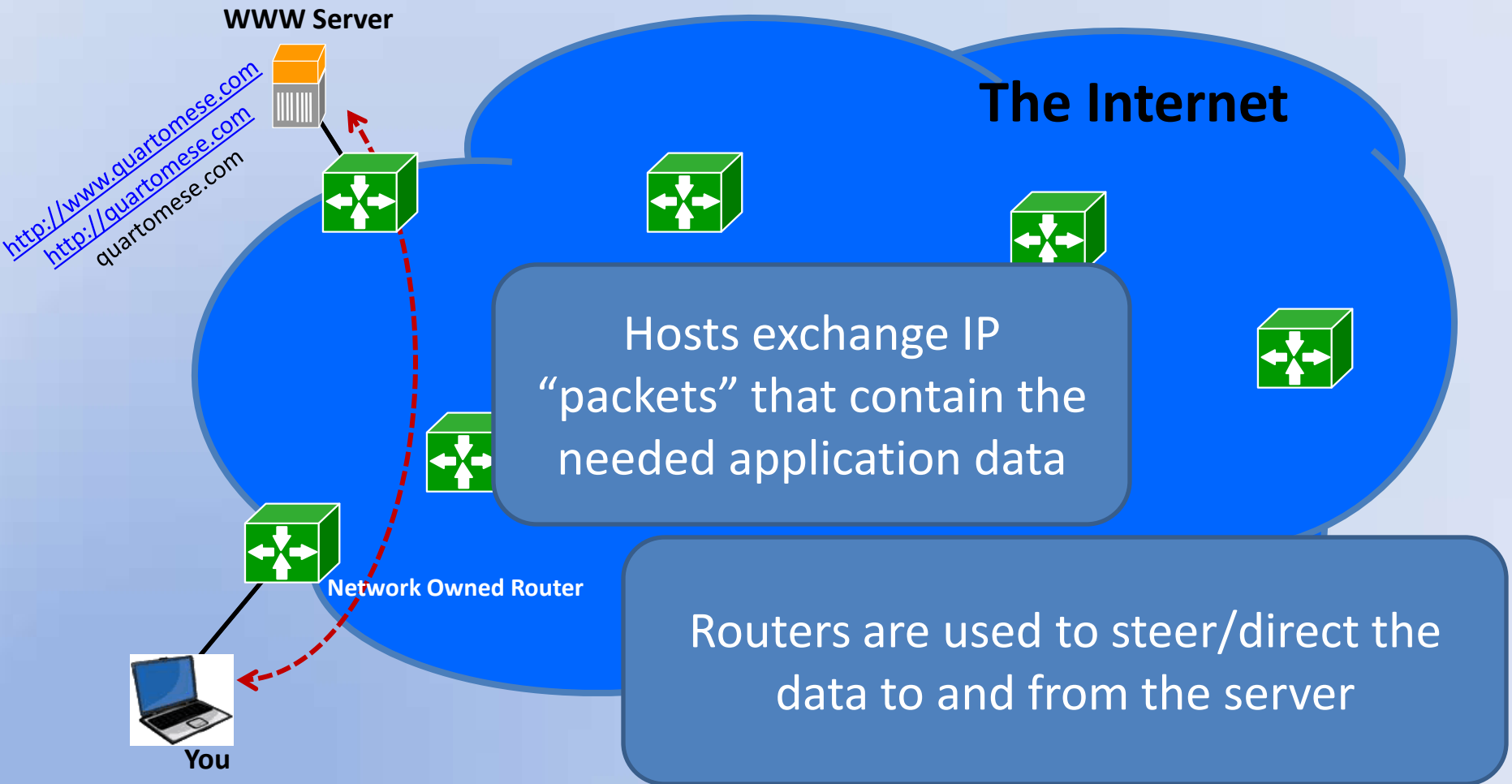
# Get WEB Page



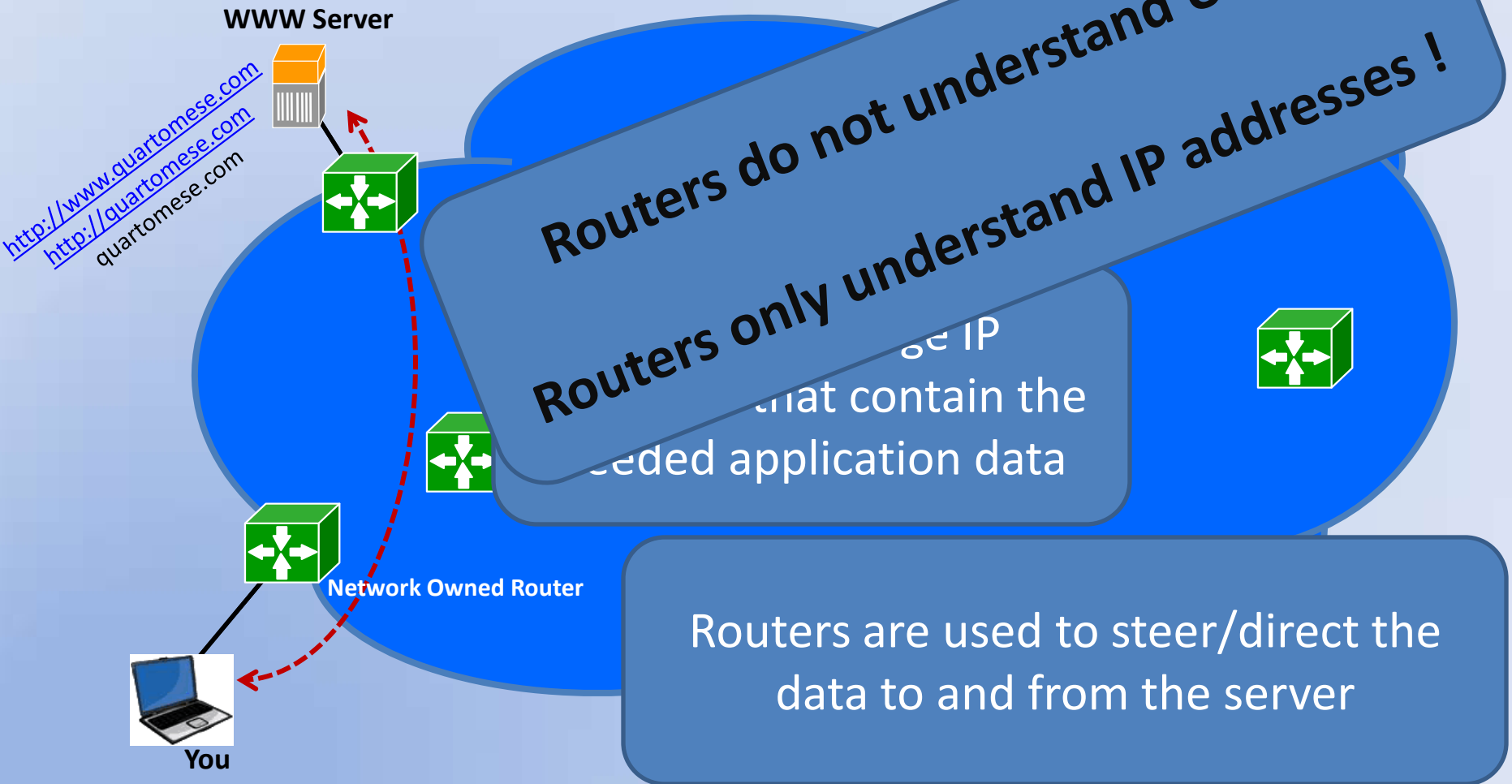
# Get WEB Page



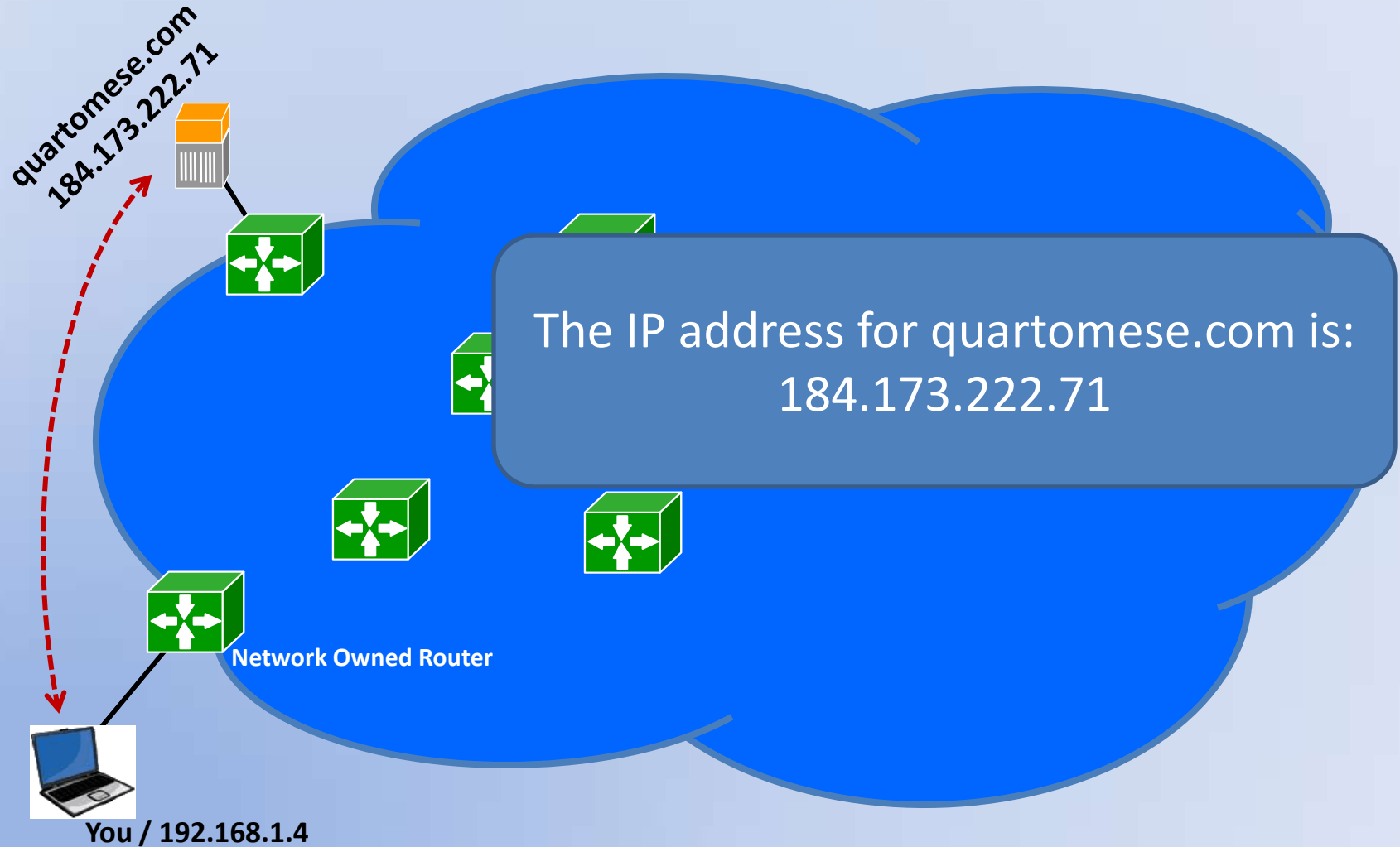
# Get WEB Page



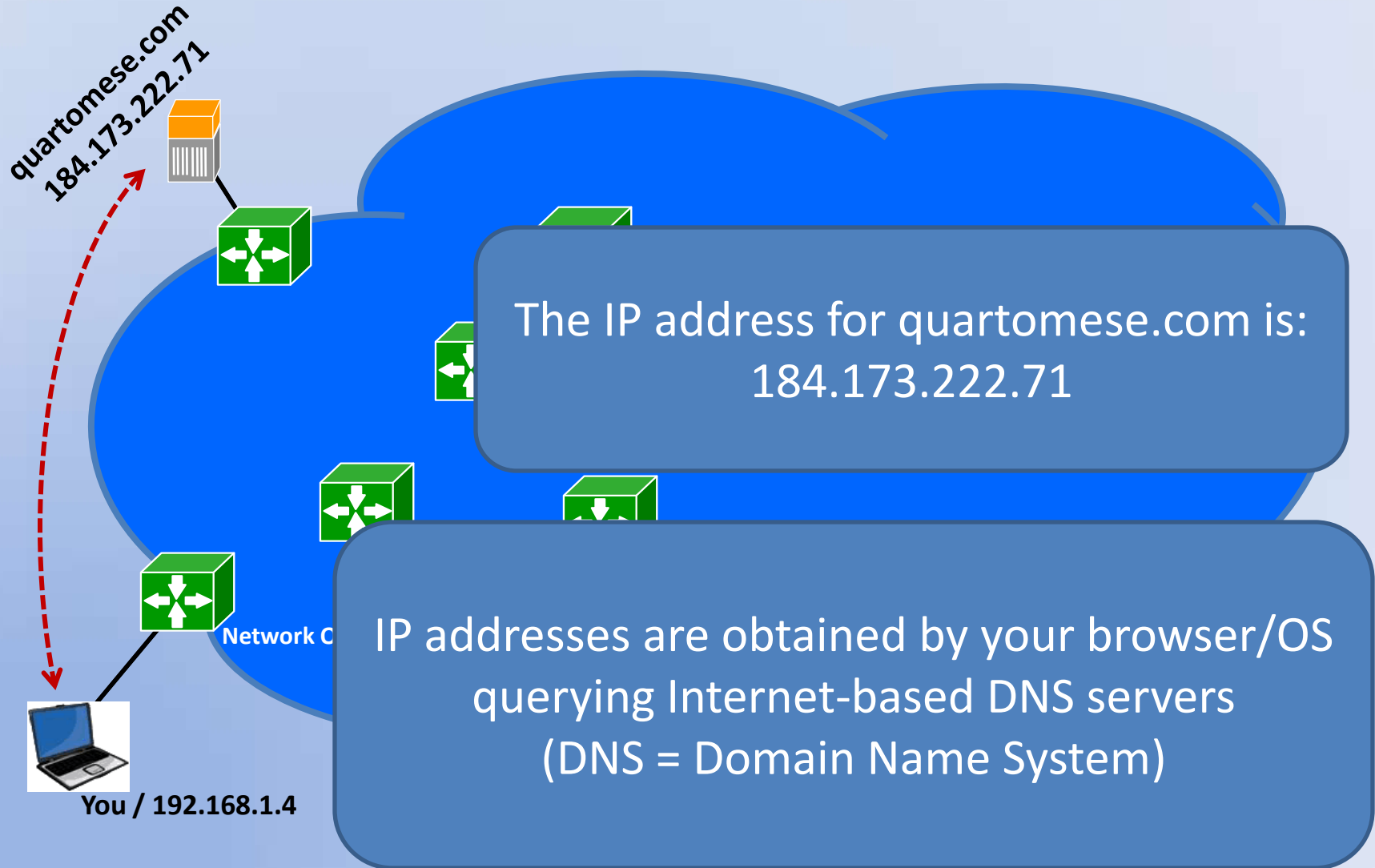
# Get WEB Page



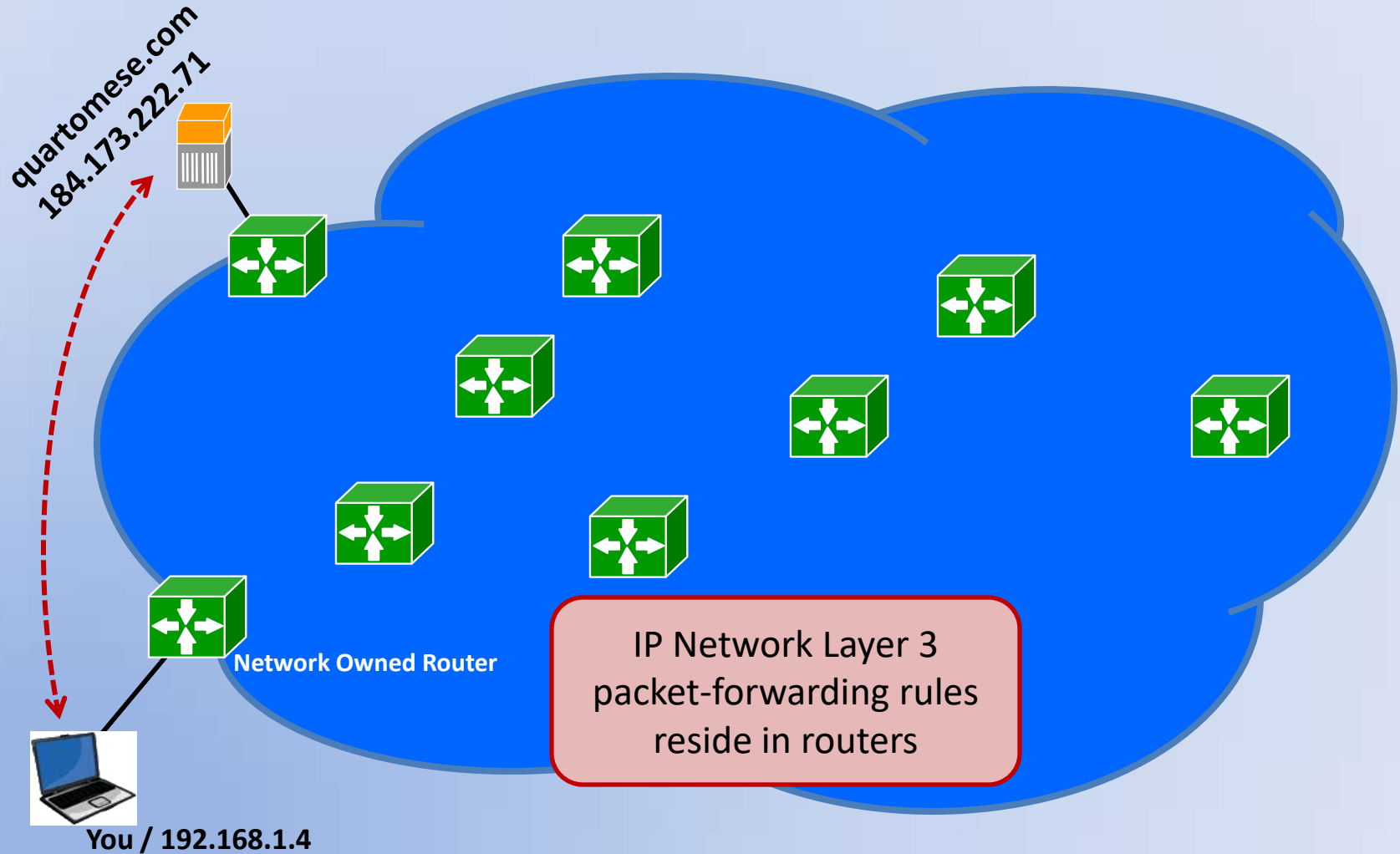
# Get WEB Page - Routing



# Get WEB Page - Routing

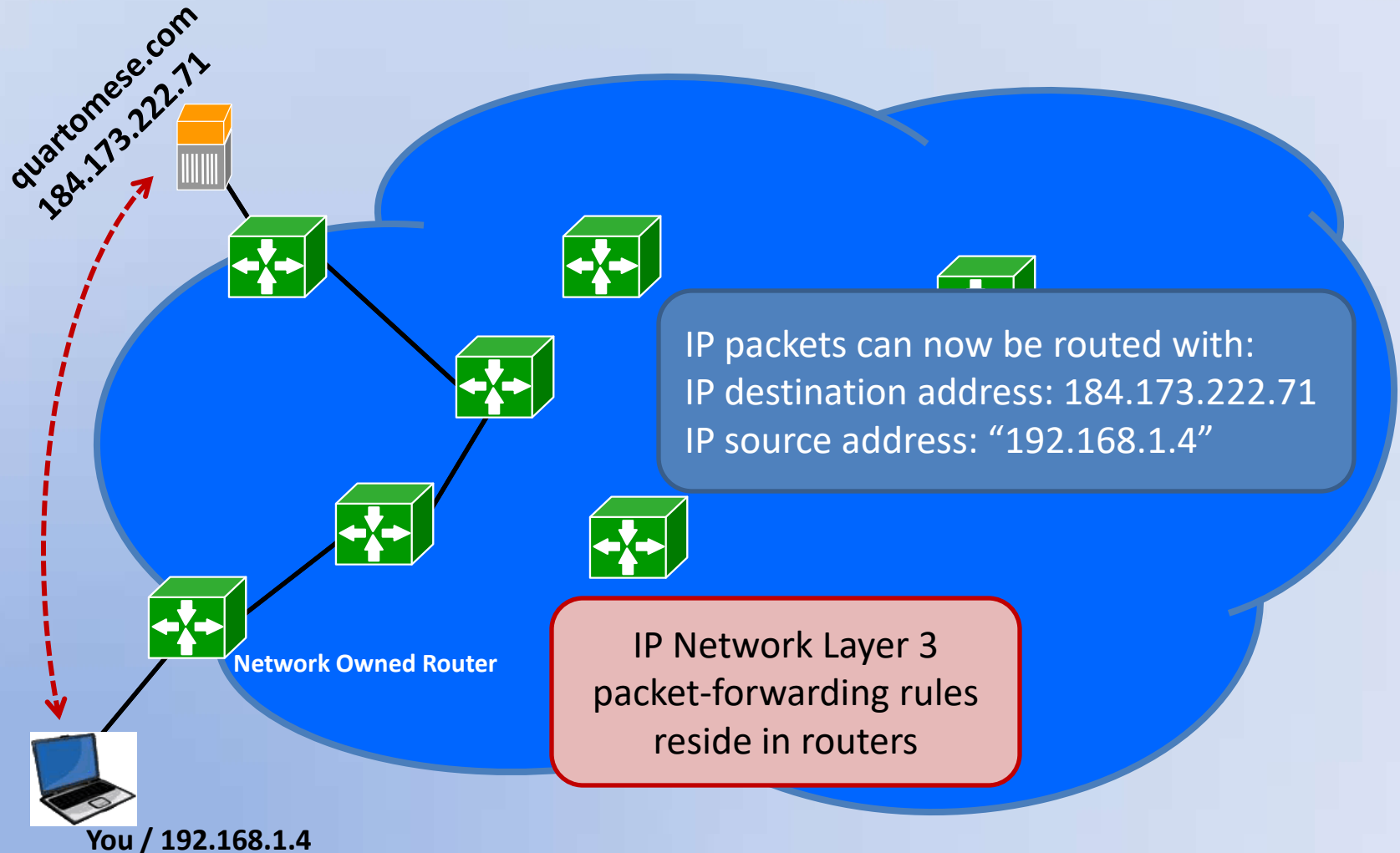


# Get WEB Page - Routing





# Get WEB Page - Routing



# MS Edge Browser

<http://quartomese.com>

## IP Address & Domain Information button

<https://www.tcpiutils.com/browse/domain/quartomese.com>

[https://www.domainiq.com/reverse\\_whois#](https://www.domainiq.com/reverse_whois#)

# The DNS Part II

# Domain Name System - DNS

- Top Level Domains
  - com, gov, edu, it, etc.
- google.com
  - google.com is called the “domain name”
- Name server
  - Computer that translates domain names into IP addresses
    - Authoritative for domains under its control
    - May cache copies of other authoritative name servers

URL: Uniform Resource Locator

<https://www.digitalocean.com/community/tutorials/an-introduction-to-dns-terminology-components-and-concepts>

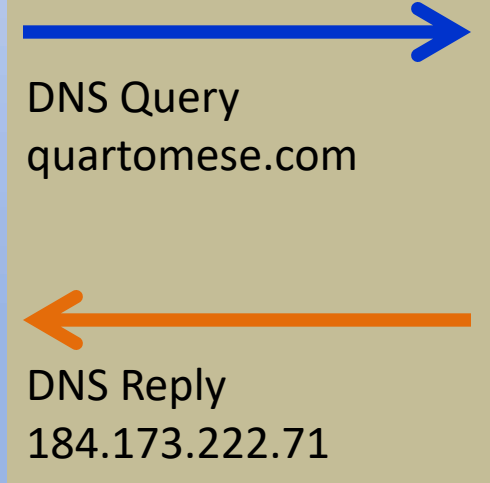
<http://blog.catchpoint.com/2014/07/01/dns-lookup-domain-name-ip-address/>

<http://blog.catchpoint.com/2010/09/17/anatomyhttp/>

# NAME SERVER – CONNECT – SSL/TLS - HTTP



IP addresses are obtained by your browser /OS querying Internet-based DNS servers (DNS = Domain Name System)



WWW Server

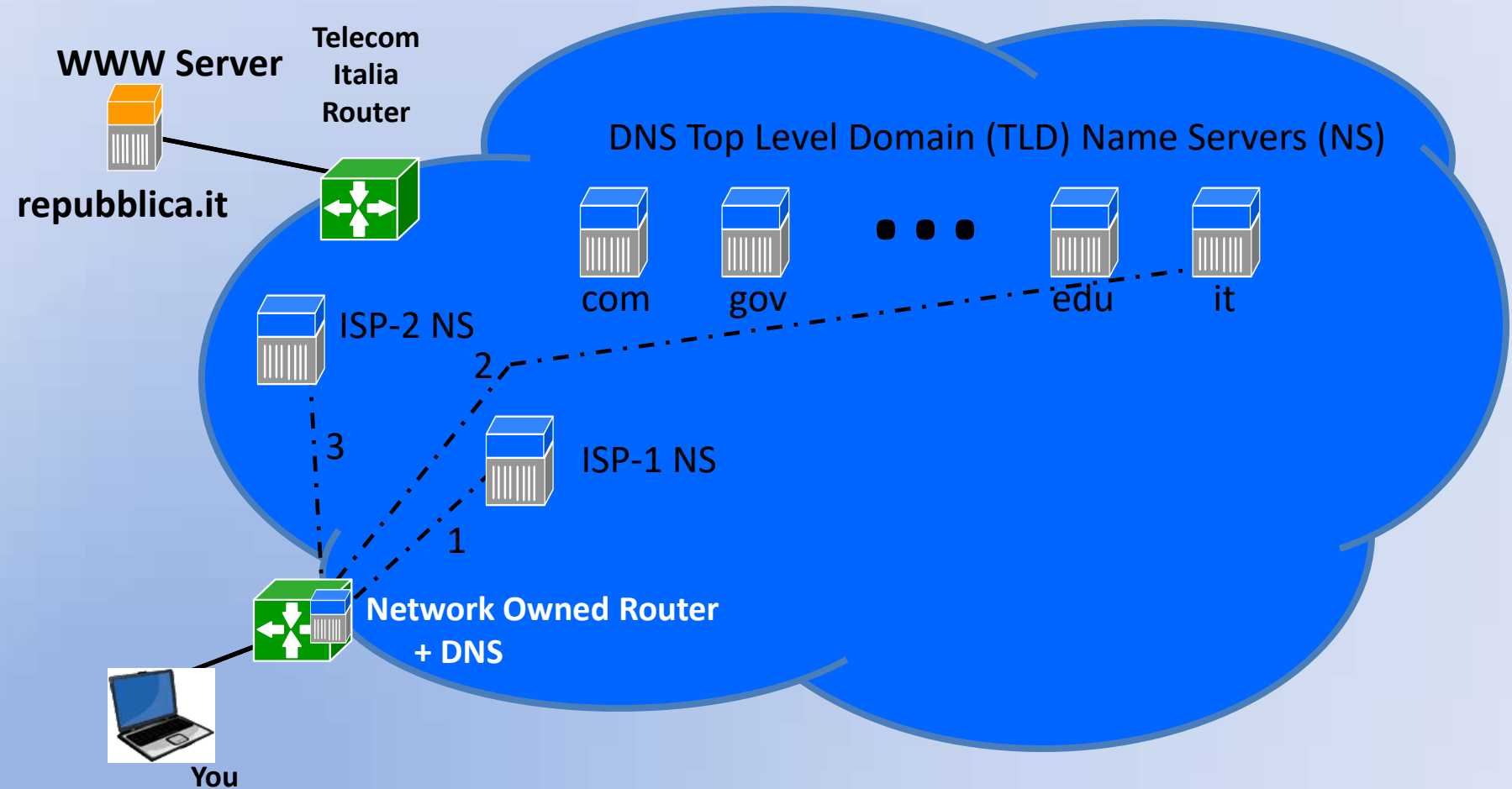


DNS Name Servers

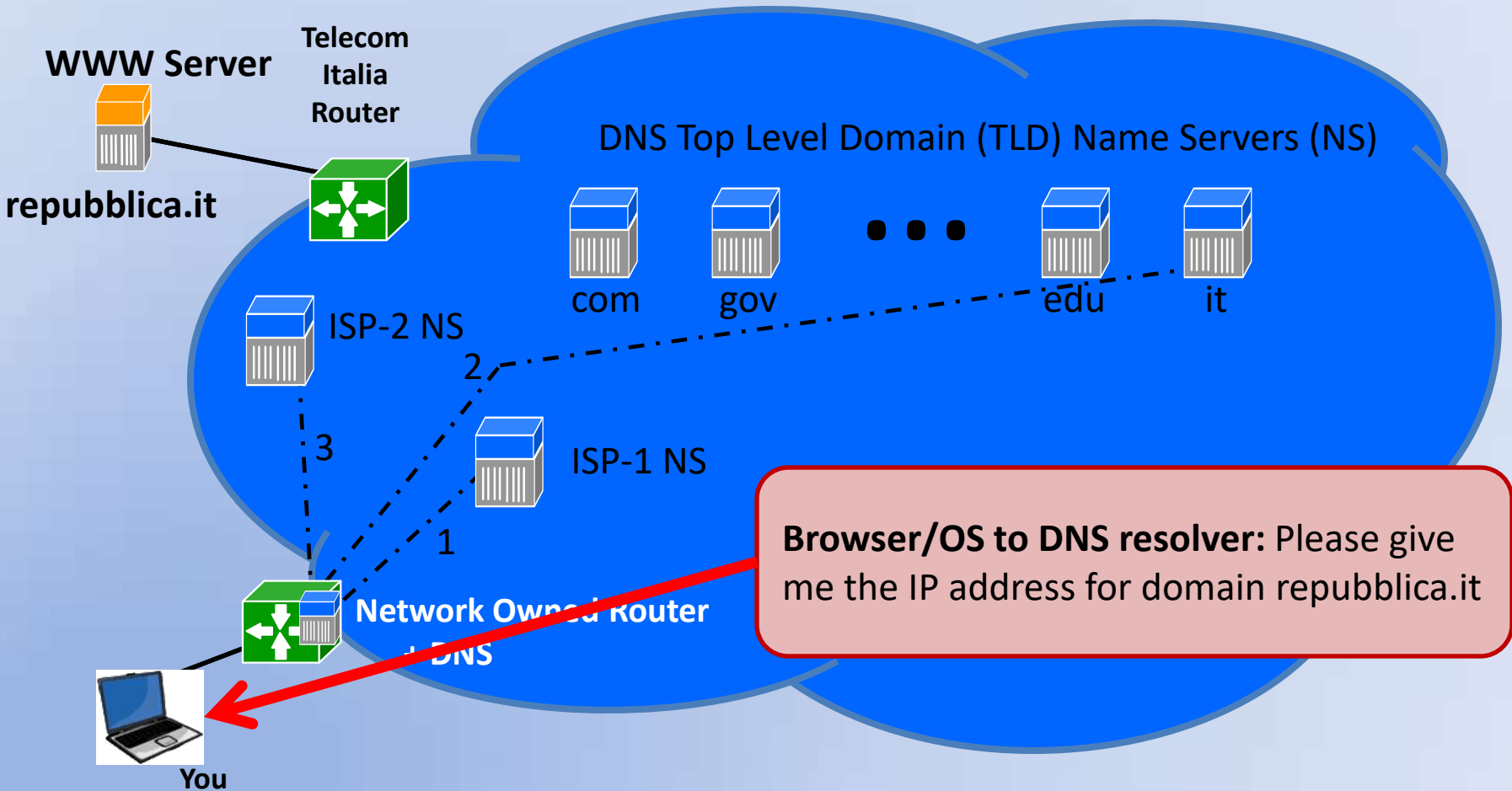
Application Layer 5
Transport Layer 4
Network Layer 3
Data Link Layer 2
Physical Layer 1

<https://gist.github.com/alyssaq/6388253>  
[http://www.eventhelix.com/RealtimeMantra/Networking/http\\_sequence\\_diagram.pdf](http://www.eventhelix.com/RealtimeMantra/Networking/http_sequence_diagram.pdf)  
<https://www.objc.io/issues/10-syncing-data/ip-tcp-http/>

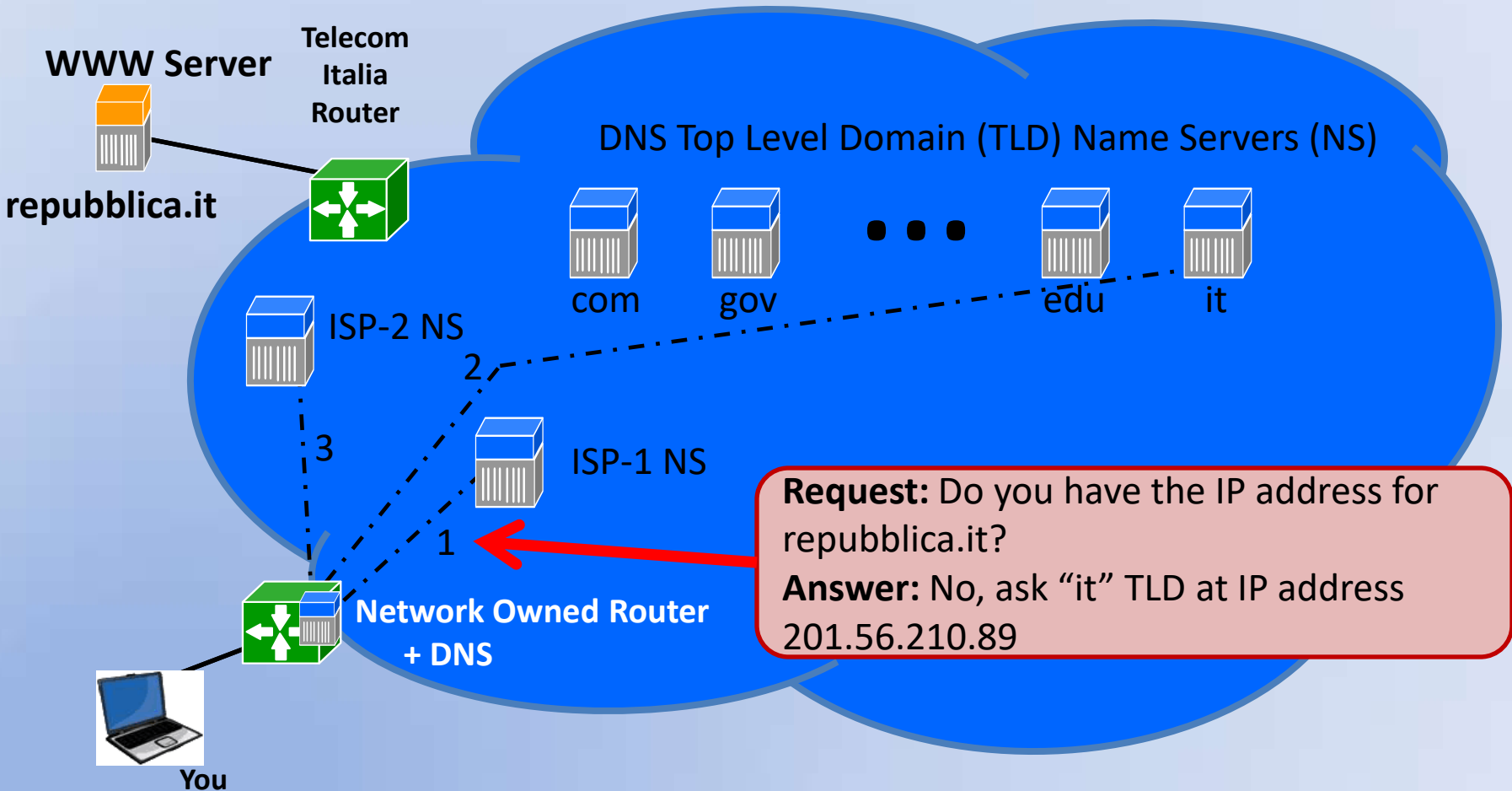
# DNS Architecture



# DNS Architecture

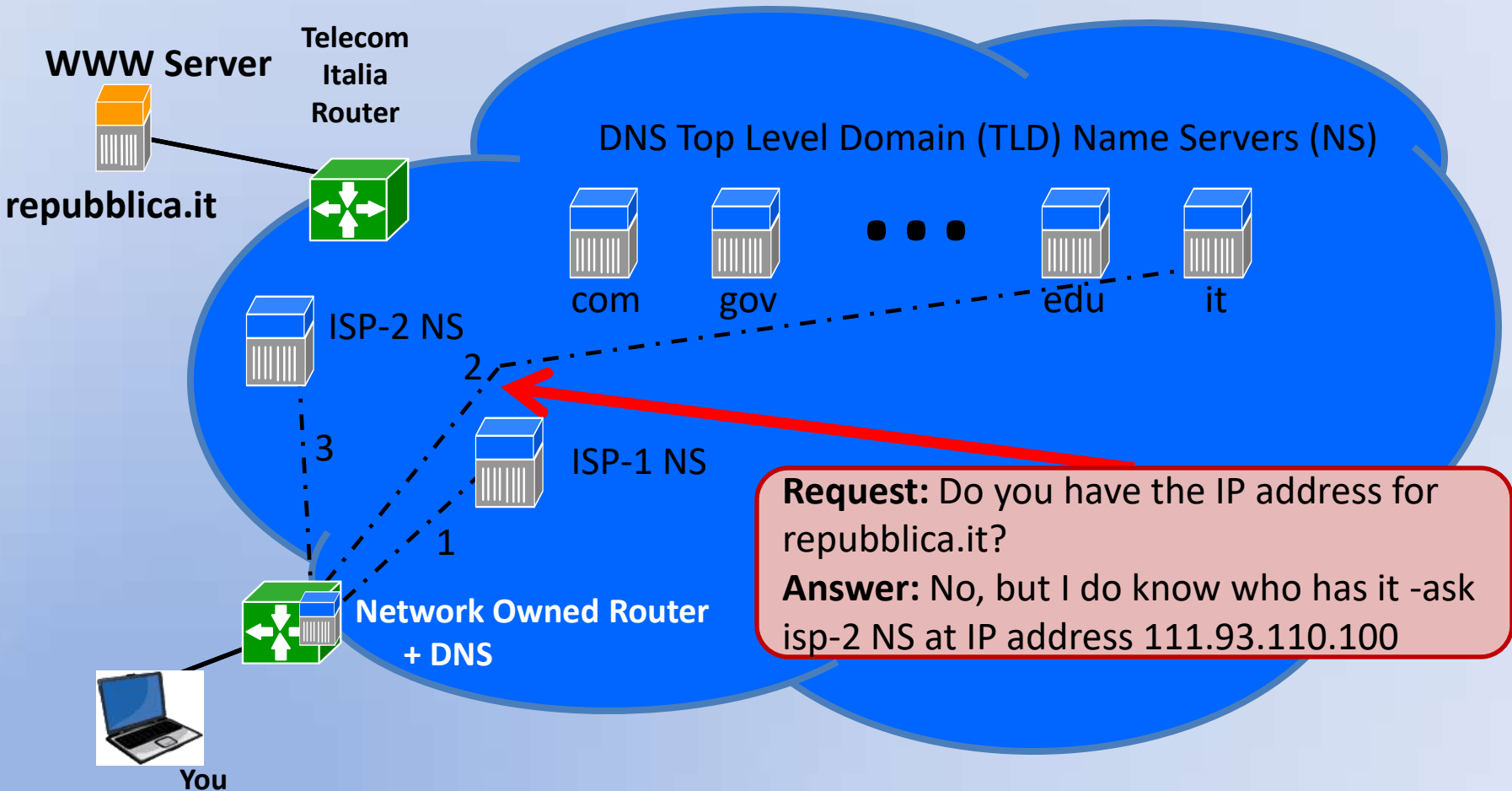


# DNS Architecture

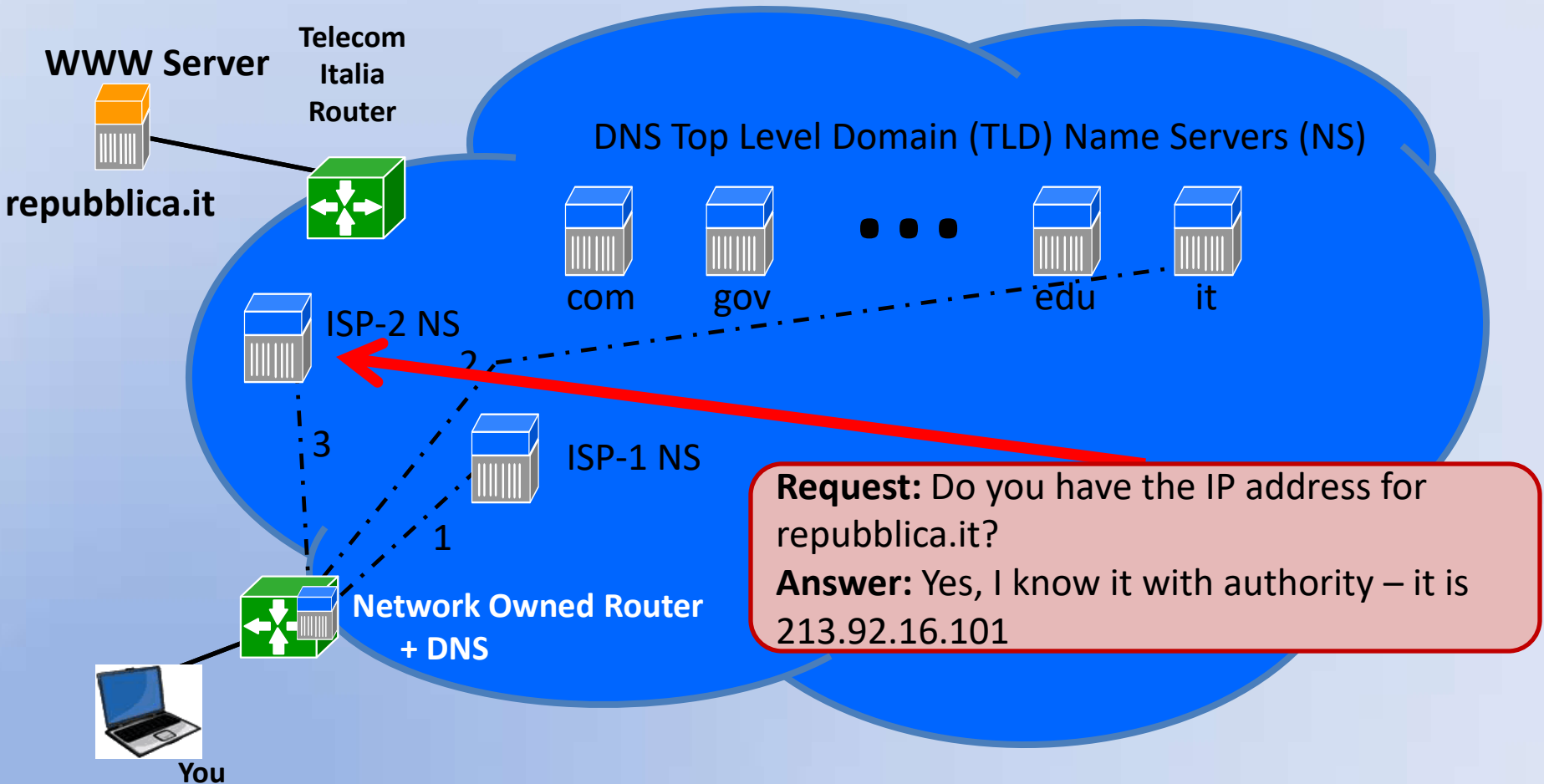




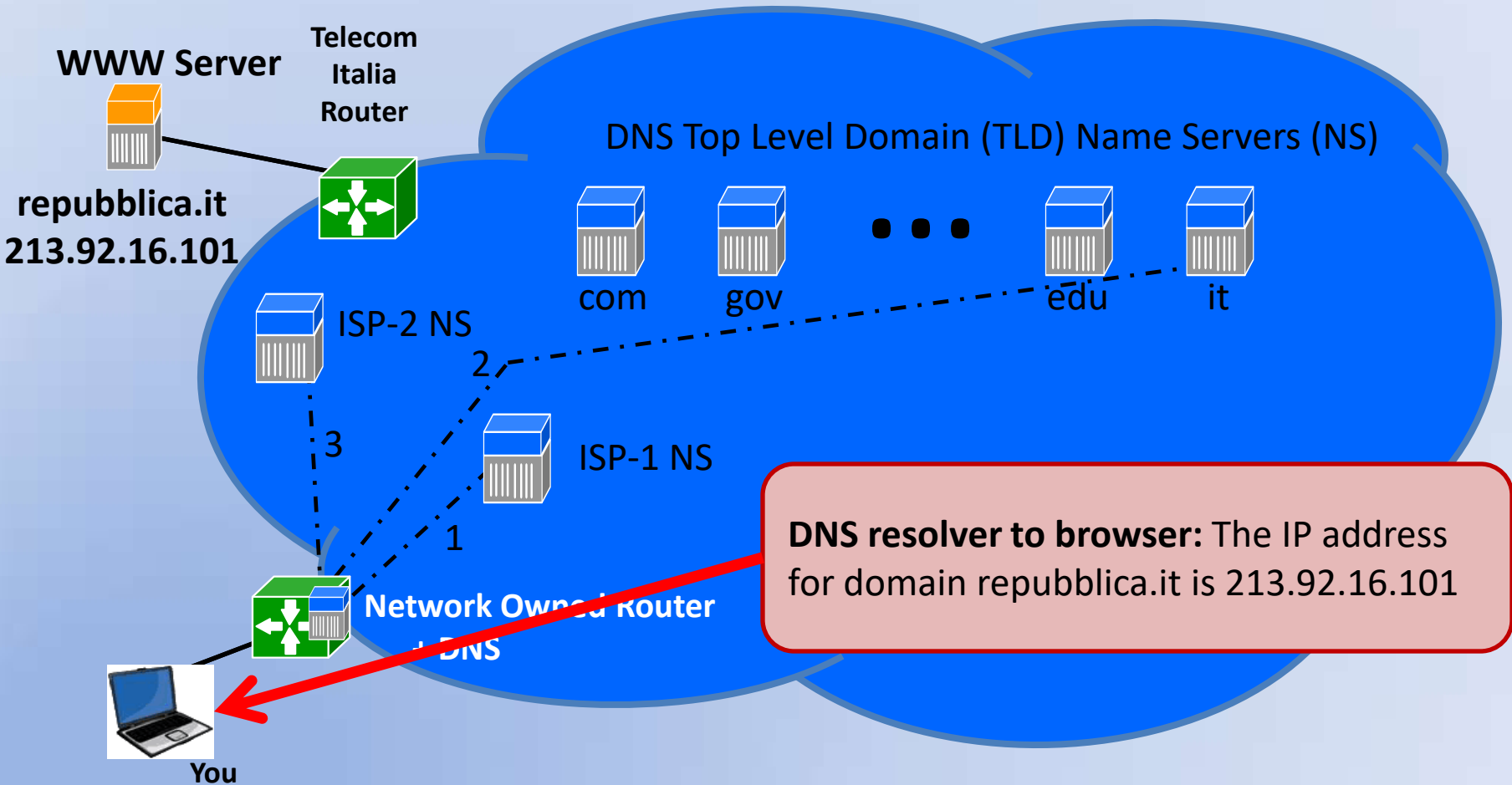
# DNS Architecture



# DNS Architecture



# DNS Architecture



# Domain Registration

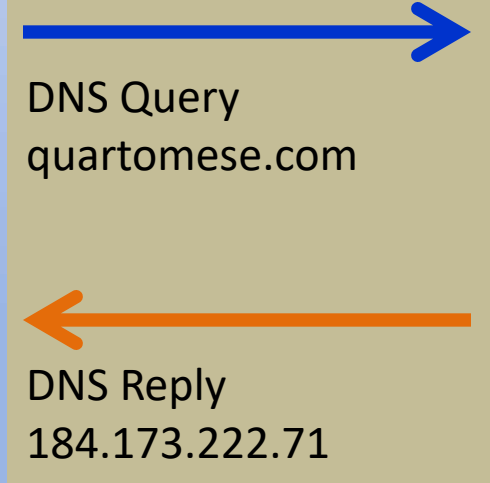
- ICANN (Internet Corporation for Assigned Names and Numbers)
  - International non-profit organization
  - Responsibilities
    - IP address and domain name management
    - Top level domain servers management
    - Registrars
      - Companies that sell domain names to individuals and organizations
      - US: Belmontdomains.com, Name.com, Register.com, many more

Get  
quatomese.com  
Webpage

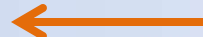
# NAME SERVER – CONNECT – SSL/TLS - HTTP



You



WWW Server



DNS Name Servers

Application
Layer 5
Transport
Layer 4
Network
Layer 3
Data Link
Layer 2
Physical
Layer 1

<https://gist.github.com/alyssaq/6388253>  
[http://www.eventhelix.com/RealtimeMantra/Networking/http\\_sequence\\_diagram.pdf](http://www.eventhelix.com/RealtimeMantra/Networking/http_sequence_diagram.pdf)  
<https://www.objc.io/issues/10-syncing-data/ip-tcp-http/>

# NAME SERVER – CONNECT – SSL/TLS - HTTP



You



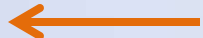
Blue arrow pointing right: DNS Query  
UDP, quartomese.com

Orange arrow pointing left: DNS Reply  
UDP, 184.173.222.71

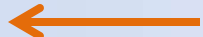
Blue arrow pointing right: SYN (TCP)  
184.173.222.71, port 80  
(192.168.1.4, port 3000)

Orange arrow pointing left: SYN\_ACK

Blue arrow pointing right: ACK



WWW Server



DNS Server



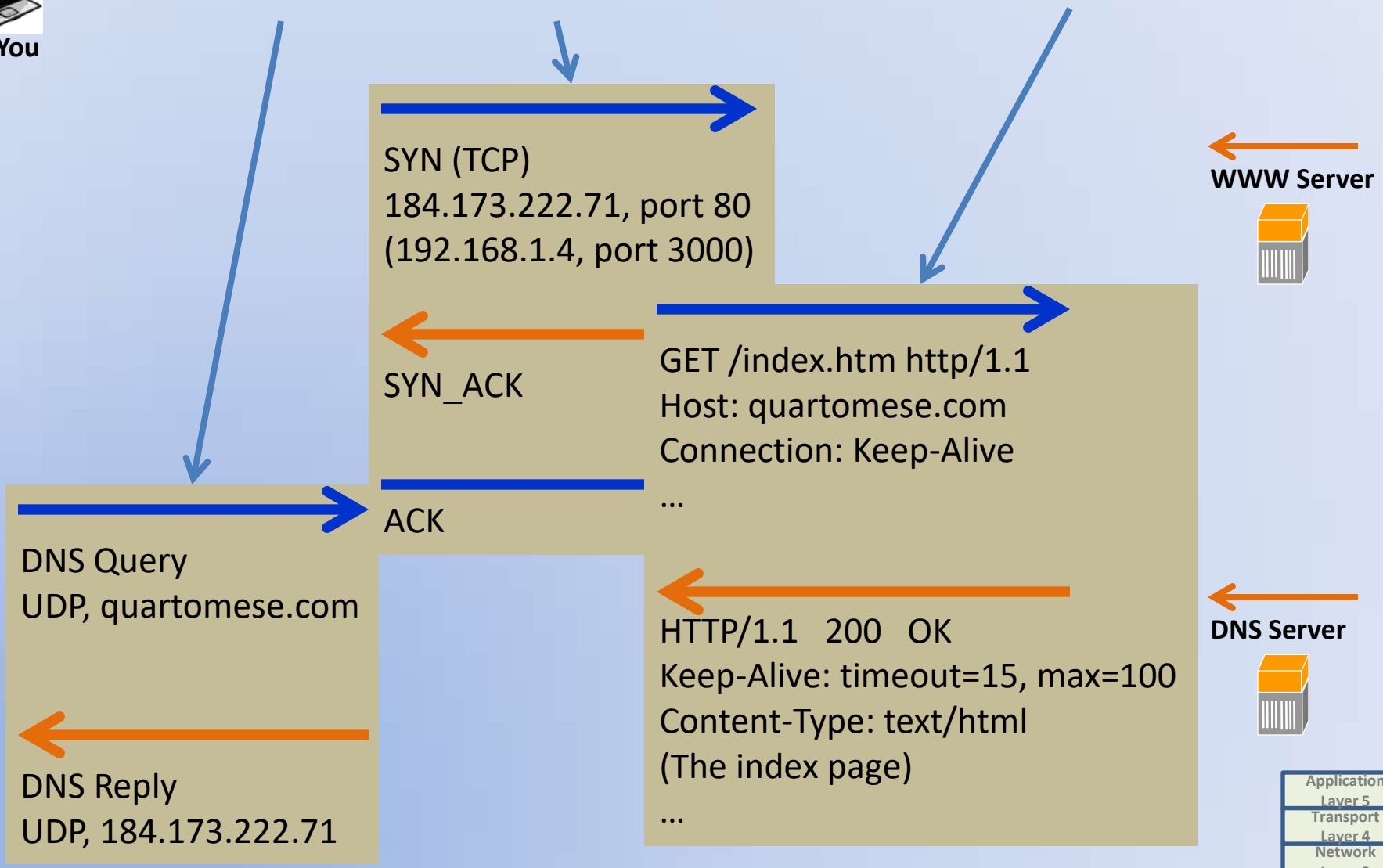
Application
Layer 5
Transport
Layer 4
Network
Layer 3
Data Link
Layer 2
Physical
Layer 1

<https://gist.github.com/alyssaq/6388253>  
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<https://www.objc.io/issues/10-syncing-data/ip-tcp-http/>

# NAME SERVER – CONNECT – SSL/TLS - HTTP



You



Application
Layer 5
Transport
Layer 4
Network
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index.htm, default.htm, index.html, default.html are all default pages  
[http://www.eventhelix.com/RealtimeMantra/Networking/http\\_sequence\\_diagram.pdf](http://www.eventhelix.com/RealtimeMantra/Networking/http_sequence_diagram.pdf)  
[https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP\\_Basics.html](https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_Basics.html)



# NAME SERVER – CONNECT – SSL/TLS - HTTP



You

→

SYN (TCP)  
184.173.222.71, port 80  
(192.168.1.4, port 3000)

←

WWW Server

**In Summary:**

1. Your browser/OS gets the IP address for your desired website
2. Your browser opens a connection to your desired website
3. Your browser makes an HTTP document request to your desired website – i.e., the page you wanted in the first place

←

HTTP/1.1 200 OK  
Keep-Alive: timeout=15, max=100  
Content-Type: text/html  
(The index page)  
...

←

DNS Server

←

DNS Reply  
UDP, 184.173.222.71

index.htm, default.htm, index.html, default.html are all default pages

[http://www.eventhelix.com/RealtimeMantra/Networking/http\\_sequence\\_diagram.pdf](http://www.eventhelix.com/RealtimeMantra/Networking/http_sequence_diagram.pdf)

[https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP\\_Basics.html](https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_Basics.html)

# NAME SERVER – CONNECT – SSL/TLS - HTTPS



You



SYN (TCP)  
54.239.25.200, port 443  
(192.168.1.4, port 3000)

← SYN\_ACK

→ ACK

→ Client "Hello" message  
SSL/TLS version options  
CipherSuites list  
Server name: amazon.com

← Server "Hello" response  
SSL/TLS & CipherSuite chosen  
Session ID  
Server certificate with server public key

→ Client authenticates certificate  
Generates pre-master secret (pms) &  
**send encrypted using server's public key**  
Generates master keys from pms  
Sends "finished" using symmetric master keys

← Server decrypts pms using server private key  
Generates master keys from pms  
Sends "finished" using symmetric master keys

← amazon.com



Asymmetric Keys  
Text encrypted with a public key can only be decrypted with the associated private key

Application
Layer 5
Transport
Layer 4
Network
Layer 3
Data Link
Layer 2
Physical
Layer 1

SSL = Secure Sockets Layer / TLS = Transport Layer Security  
<https://blogs.msdn.microsoft.com/kaushal/2013/08/02/ssl-handshake-and-https-bindings-on-iis/>  
<http://www.moserware.com/2009/06/first-few-milliseconds-of-https.html>  
<http://security.stackexchange.com/questions/20803/how-does-ssl-tls-work>  
[https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP\\_SSL.html](https://www.ntu.edu.sg/home/ehchua/programming/webprogramming/HTTP_SSL.html)  
[http://www.ibm.com/support/knowledgecenter/SSFKSJ\\_7.1.0/com.ibm.mq.doc/sy10660.htm](http://www.ibm.com/support/knowledgecenter/SSFKSJ_7.1.0/com.ibm.mq.doc/sy10660.htm)

# Packet Delivery Between Hosts & Routers



You

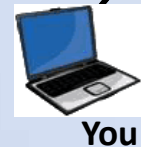
# How Do “You” Connect To An ISP



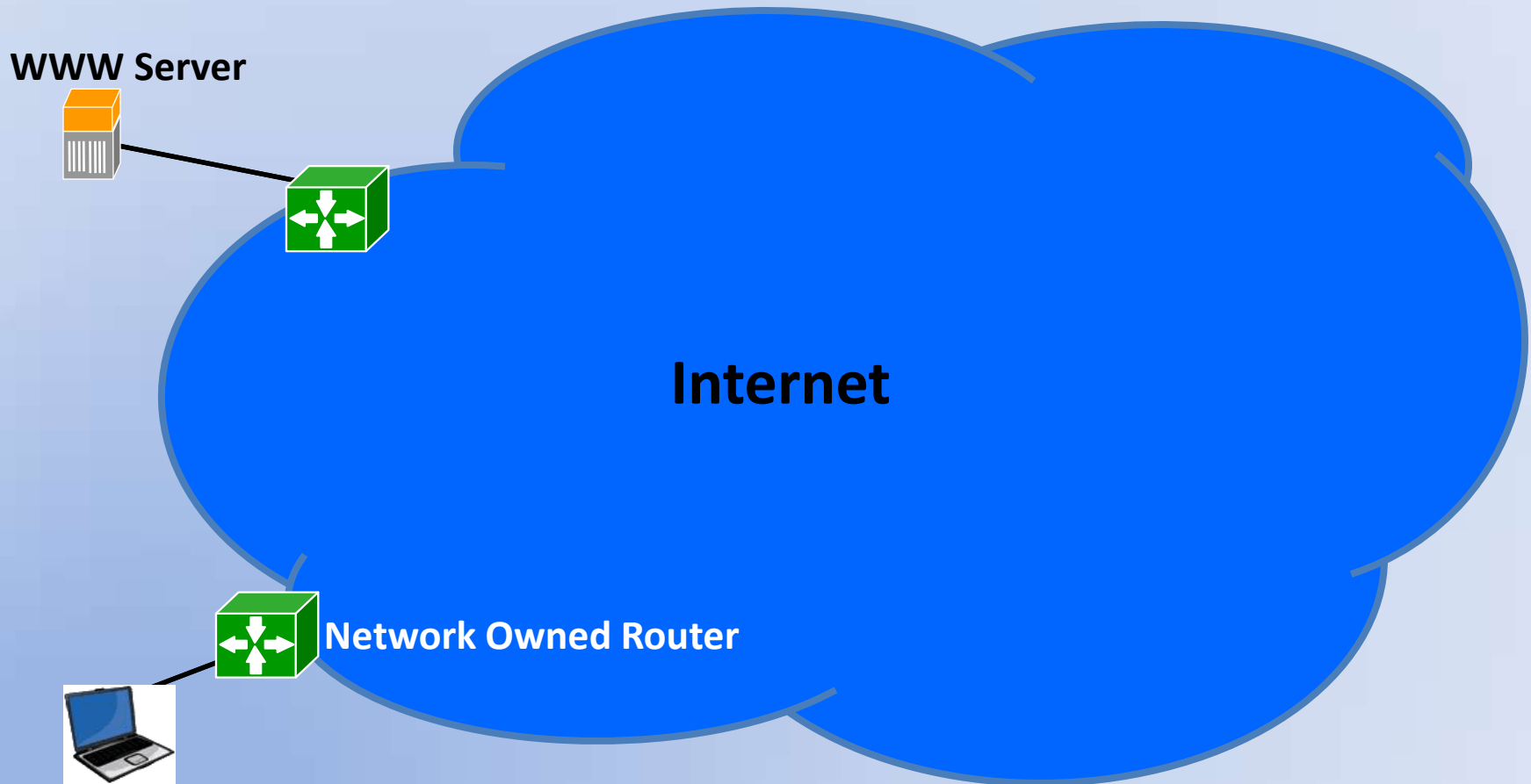
**You**

# How Do “You” Connect To An ISP

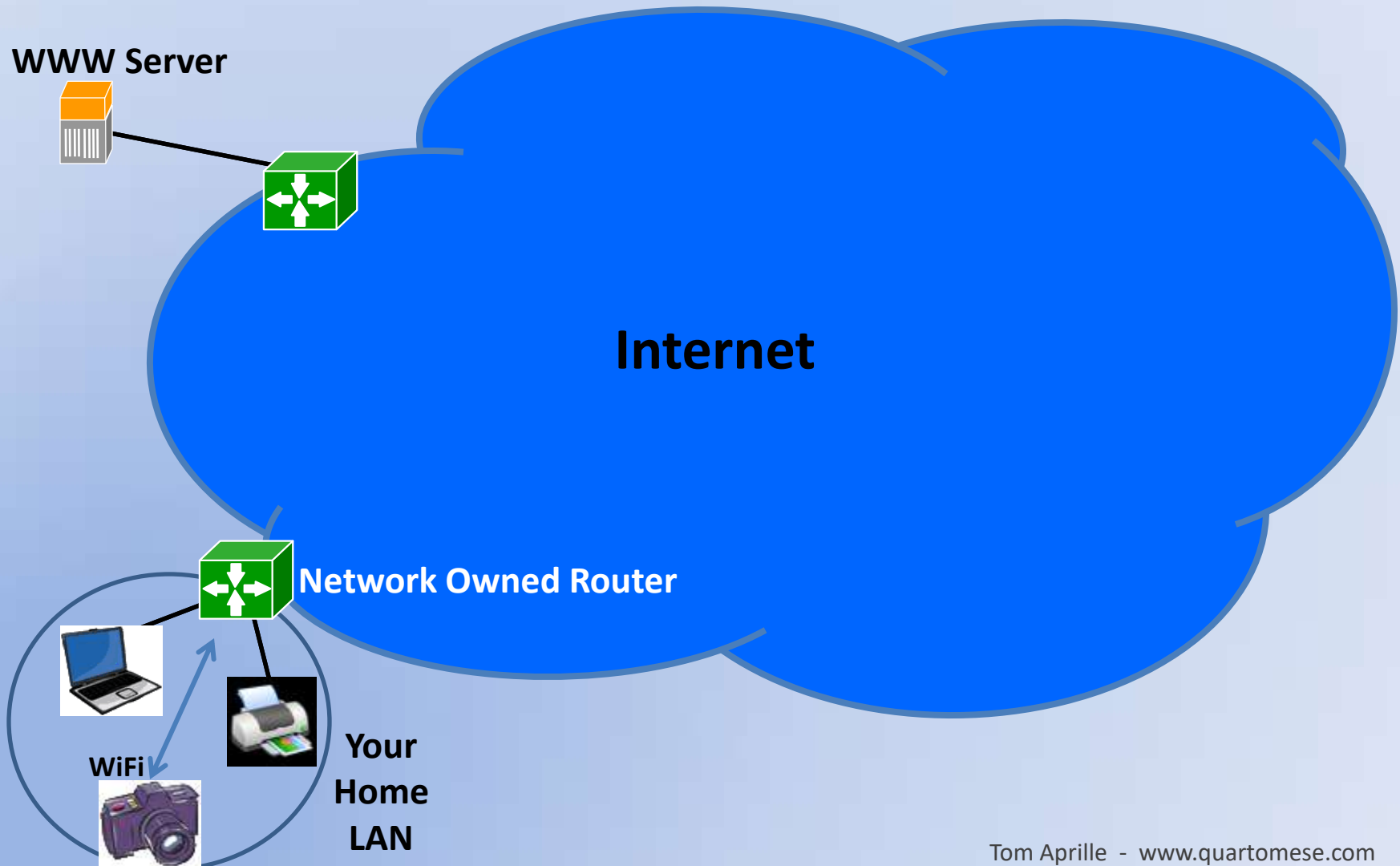
- You connect via
  - **Home LAN (Including WiFi)**
  - Public WiFi hot spots
  - Smartphones (Mobile network)
  - Acoustic couplers



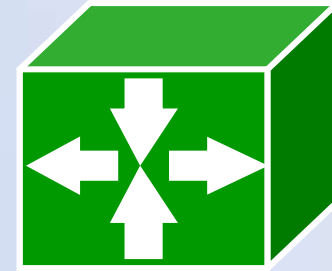
# Your Home Local Area Network (LAN)



# Your Home Local Area Network (LAN)



# ISP Supplied Network Router

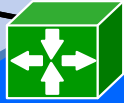


Home router



# Your Home Local Area Network (LAN)

WWW Server



Internet

The LAN provides for communications among its attached devices (routers, PCs, printers, etc.)



Network Owned Router



WiFi

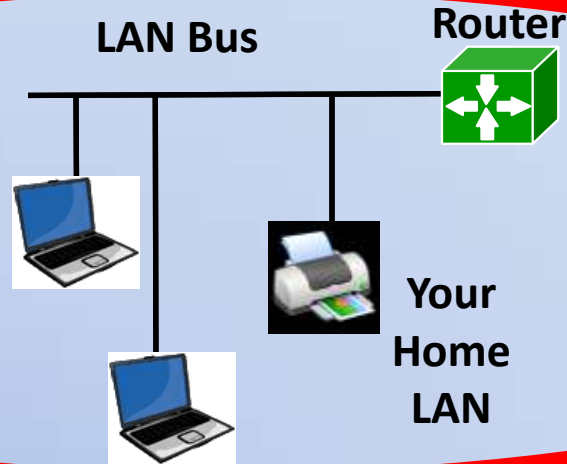


Your Home LAN

# Ethernet LAN Architecture

- Bus

- Half duplex
- CSMA/CD

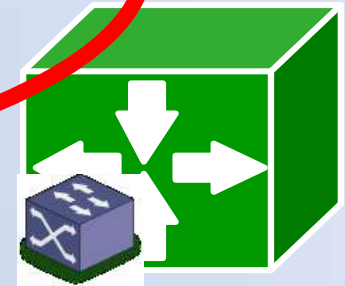


- Switch

- Full duplex
- Auto negotiate on startup
  - Speed, full/half duplex, etc
- RS45 jack with twisted pair cable
  - 10/100BASE-T uses 2 of 4 pairs
  - Manchester coding



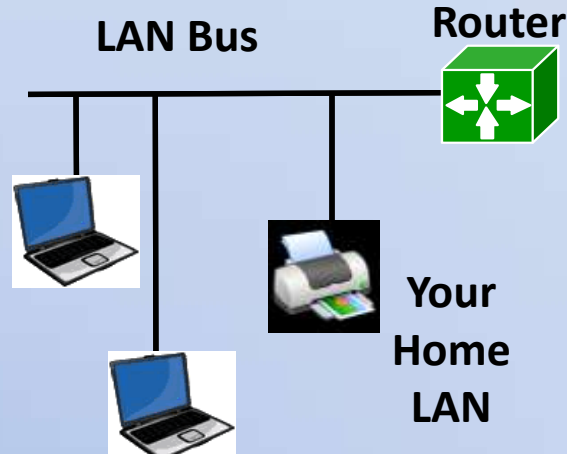
- Token Ring



# Ethernet LAN Architecture

- Bus

- Half duplex
- CSMA/CD

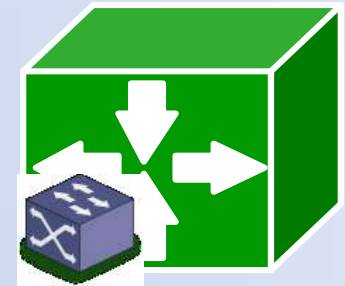


- Switch

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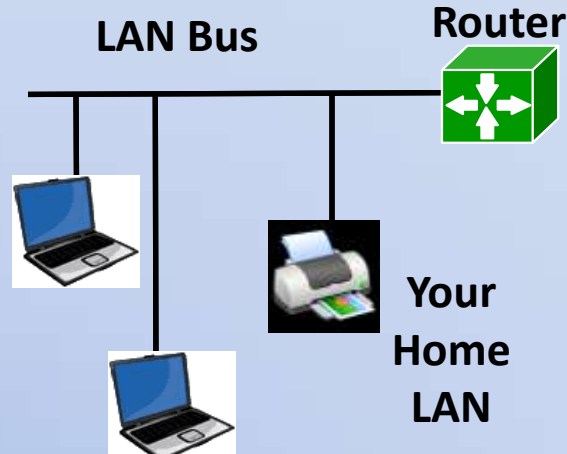
- Token Ring



# Ethernet LAN Architecture

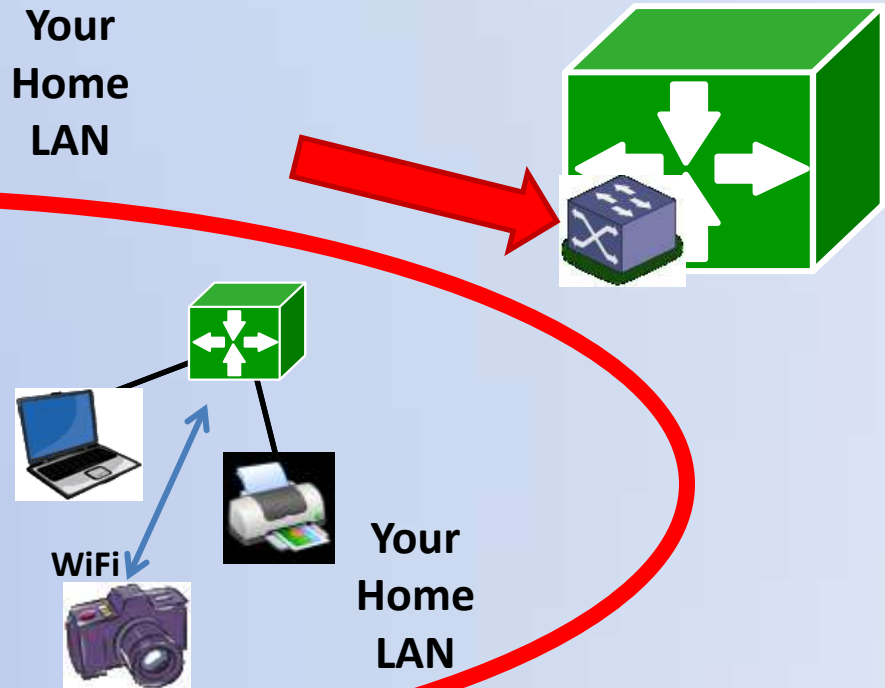
- Bus

- Half duplex
- CSMA/CD



- Switch

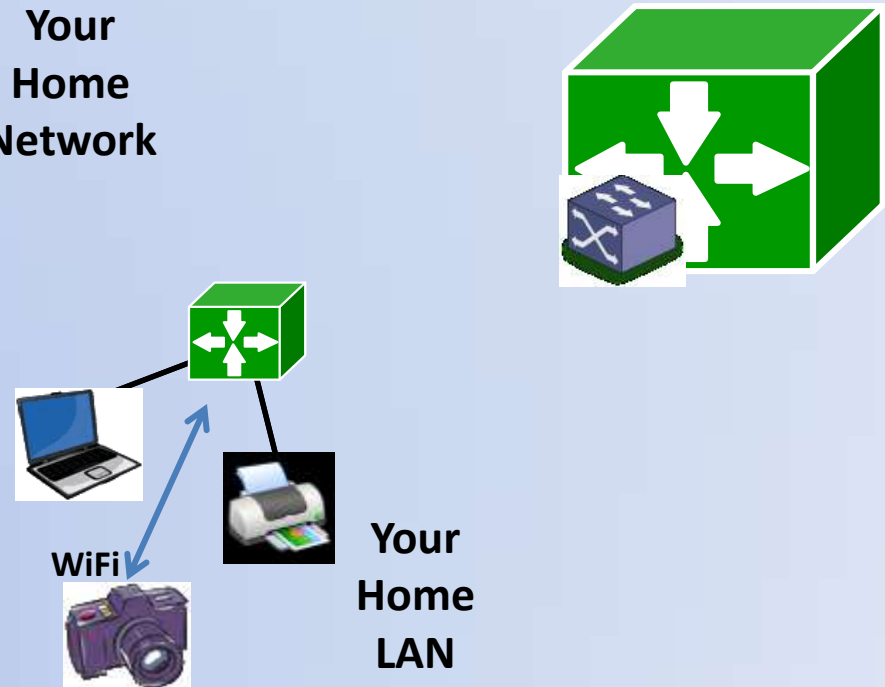
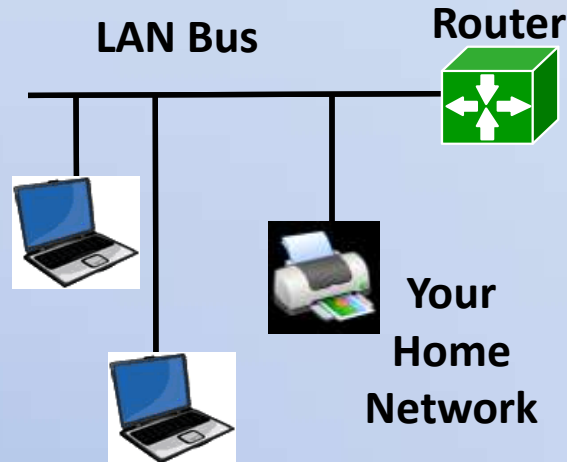
- Full duplex
- Auto negotiate on startup
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  - 10/100BASE-T uses 2 of 4 pairs



- Token Ring

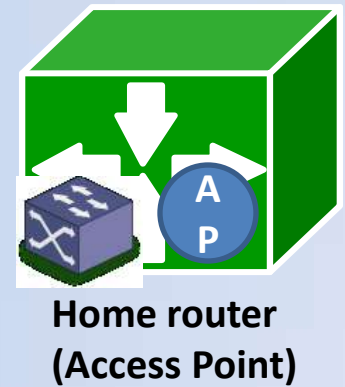
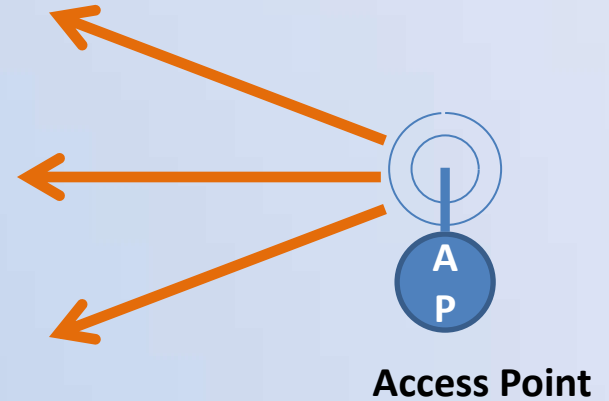
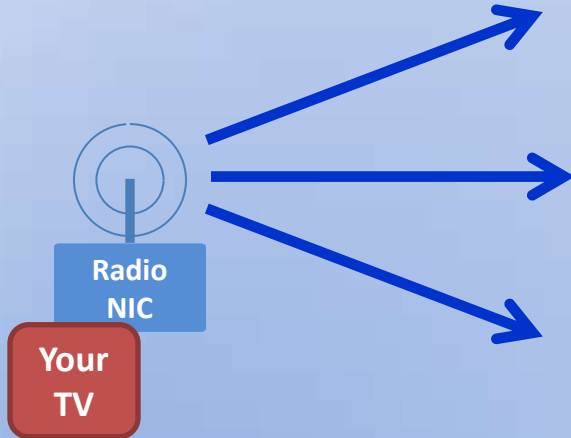
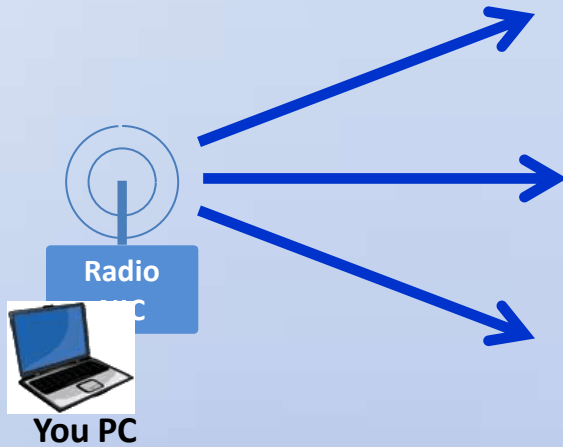
# Ethernet LAN Architecture

- Bus
  - Half duplex
  - CSMA/CD
- Switch
  - Full duplex
  - Auto negotiate on startup
    - Speed, full/half duplex, etc
  - RS45 jack with twisted pair cable
    - 10/100BASE-T uses 2 of 4 pairs



- Token Ring

# WiFi



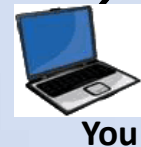
NIC: Network Interface Controller

<https://www.cs.umd.edu/class/fall2009/cmsc417/Slides/KC7IIB - Demystifying the 802.11 Protocol.pdf>

[https://en.wikipedia.org/wiki/Beacon\\_frame](https://en.wikipedia.org/wiki/Beacon_frame)

# How Do “You” Connect To An ISP

- You connect via
  - **Home LAN (Including WiFi)**
  - Public WiFi hot spots
  - Smartphones (Mobile network)
  - Acoustic couplers



# How Do “You” Connect To An ISP

- You connect via
  - **Home LAN (Including WiFi)**
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How does an ISP connect to you ?



# How Does an ISP Connect To “You”

- You connect via
  - Home LAN (Including WiFi)
  - Public WiFi hot spots
  - Smartphones (Mobile network)
  - Acoustic couplers
- ISPs connect to you via
  - Router plus WAN
    - LANs
    - Coax cable
    - Fiber / DSL
  - Satellite
  - Cell Towers



Router

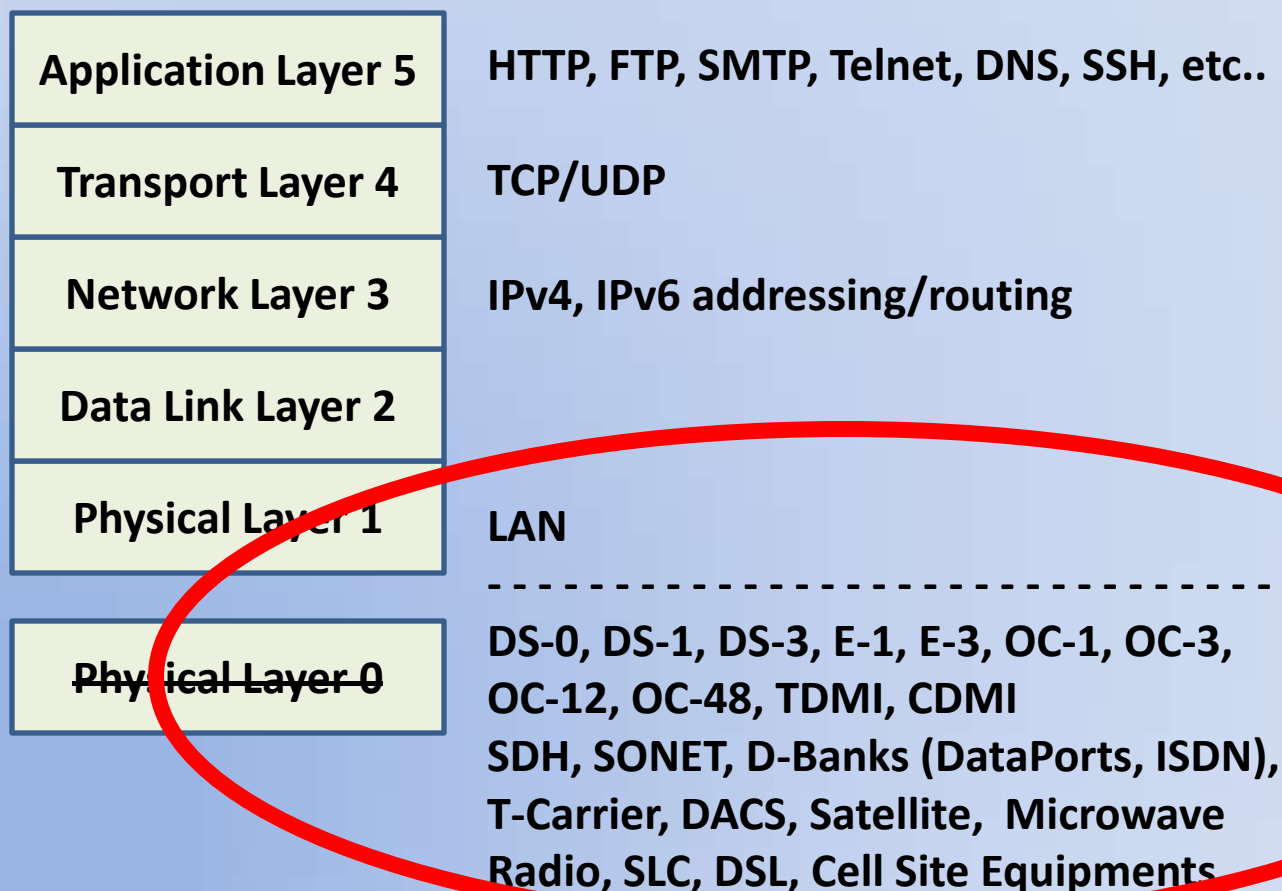
Twisted pair

Coax

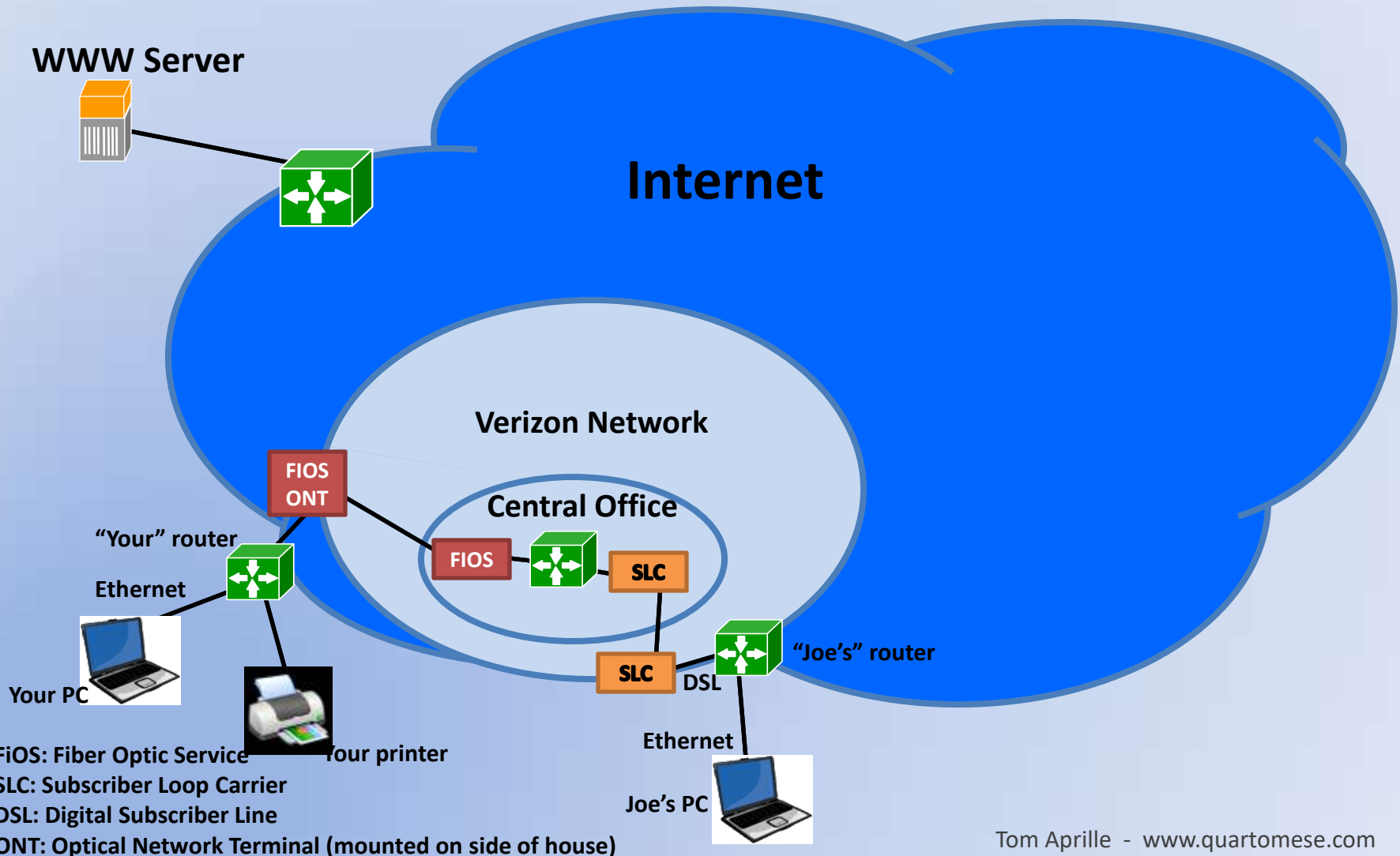
Fiber



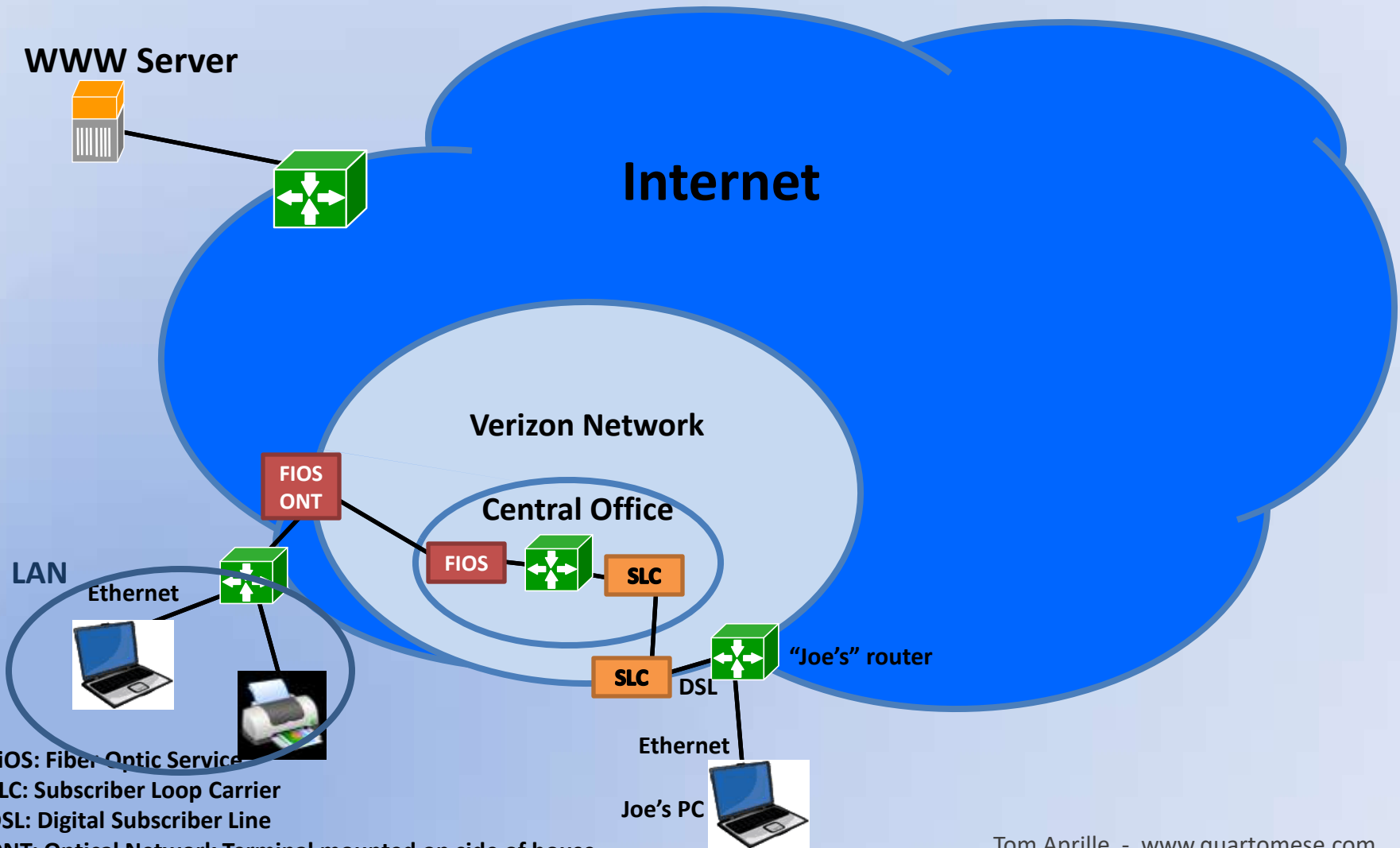
# ISP WAN Physical Layer 1 (0)



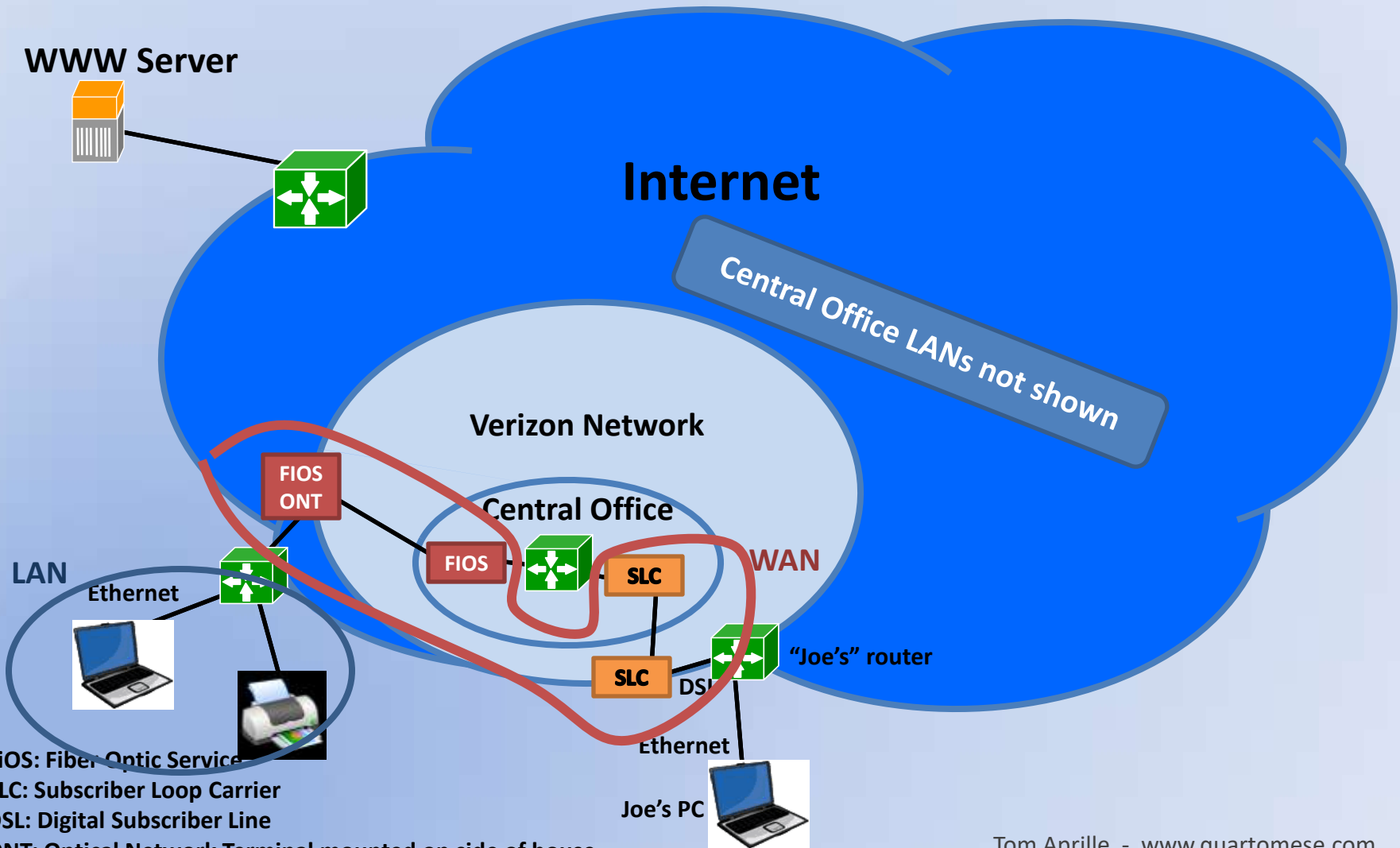
# Your ISP's WAN Network



# Your ISP's WAN Network



# Your ISP's WAN Network



FiOS: Fiber Optic Service  
SLC: Subscriber Loop Carrier  
DSL: Digital Subscriber Line  
ONT: Optical Network Terminal mounted on side of house

# How Does An Ethernet LAN Work

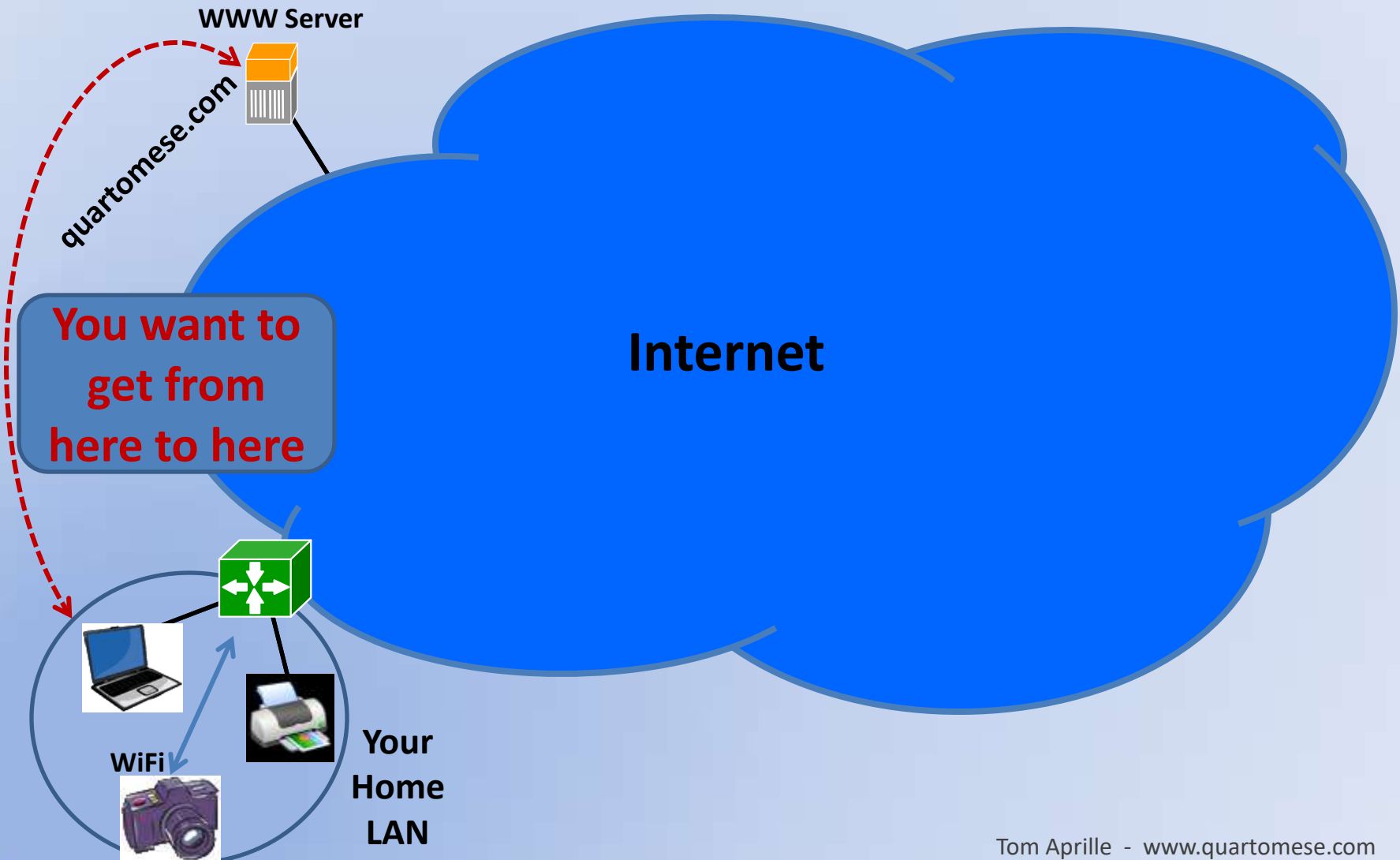


# Ethernet Does An WiFi Work

The LAN provides for communications among its attached devices (routers, PCs, printers, etc.)

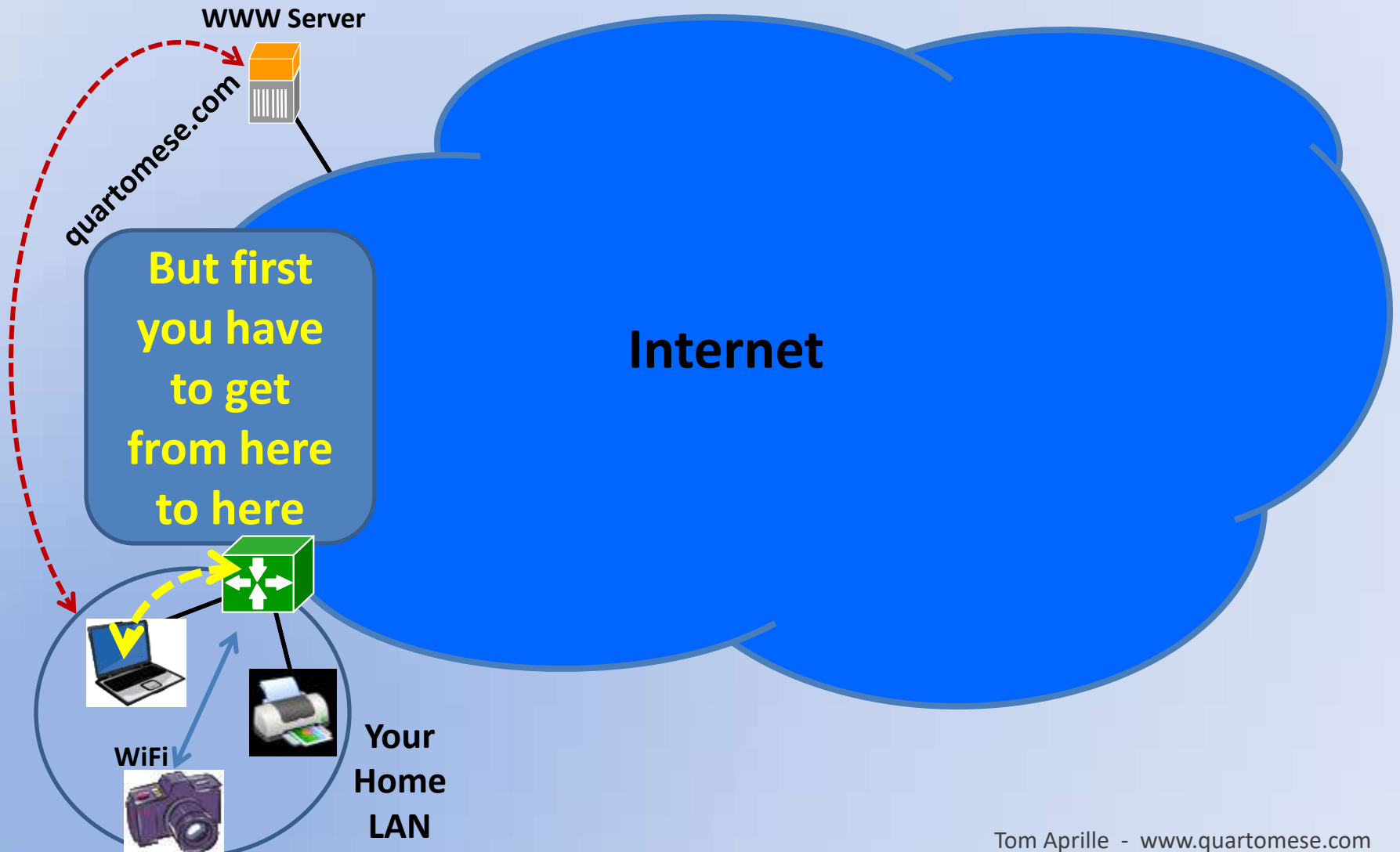


# How Does The Ethernet LAN Work





# How Does The Ethernet LAN Work



# How Does The Ethernet LAN

The LAN interface does not understand Domain Names

Internet

But first  
you have  
to get  
from here  
to here

WWW Server

quartomese.com



WiFi



Your  
Home  
LAN

# How Does The Ethernet LAN

WWW Server

quartomese.com



But first  
you have

to get

from

to

The LAN interface does not understand Domain Names

The LAN interface does not understand IP addresses !!!



WiFi



Your  
Home  
LAN

# How Does The Ethernet LAN Interface

WWW Server

quartomese.com



But first  
you have  
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The LAN interface does not understand IP addresses !!!

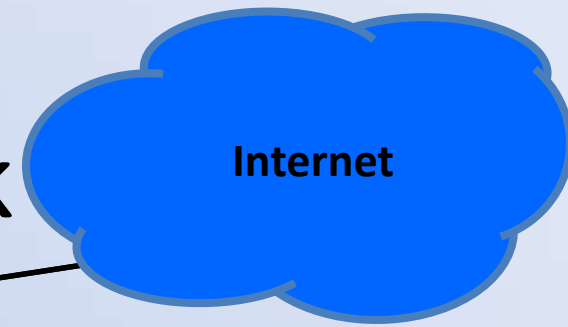
The LAN interface only understands MAC addresses  
MAC = Media Access Controller



WiFi



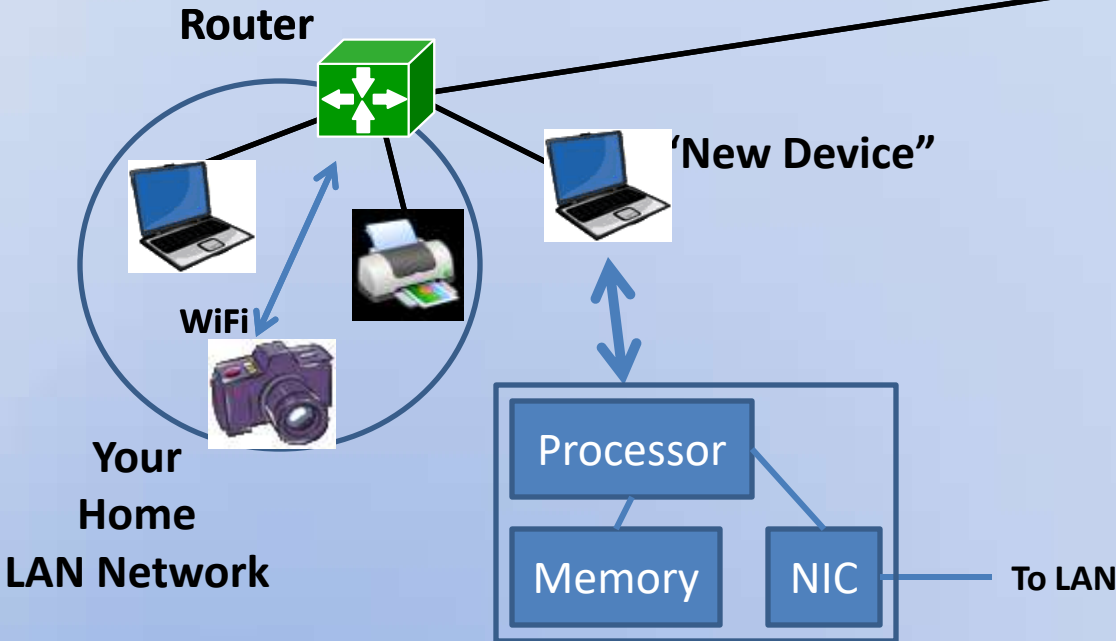
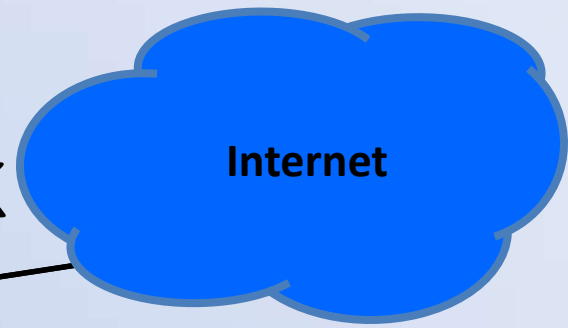
# Your LAN Network



- Initial LAN technology developed by Robert Metcalfe in 1973
- Ethernet LAN is the physical layer of the 5-layer stack
- Each device on LAN has a unique 6-byte/48-bit MAC address (34:E4:DA:49:2E:43)
- Devices (hosts/routers) communicate amongst each other using MAC addressing

Application
Layer 5
Transport
Layer 4
Network
Layer 3
Data Link
Layer 2
Physical
Layer 1

# Your LAN Network



## Network Interface Controller (NIC)

- All devices connected to the LAN have a NIC [function]
- Receives and transmits from/to the Ethernet LAN
- Has a unique 6-byte MAC Address
  - 3-bytes manufacture designation – 3-bytes serial number

# Connecting To The Network

## Dynamic Host Configuration Protocol

- Your PC connects to the Network
- PC NIC DHCP client sends a DHCP-Discover broadcast message to the network requesting an IP address assignment
  - Routers do not forward MAC broadcast messages
- DHCP server sends a DHCP-Offer broadcast message offering the PC client to lease an available IP address
  - DHCP server resides in the ISP supplied router
  - The DHCP server usually also supplies the gateway and DNS IP addresses
- Private Network (your LAN)Addresses
  - 192.168.x.x and 10.x.x.x

DHCP: Dynamic Host Configuration Protocol

ARP: Address Resolution Protocol

[https://technet.microsoft.com/en-us/library/cc780760\(v=ws.10\).aspx](https://technet.microsoft.com/en-us/library/cc780760(v=ws.10).aspx)

<http://whatismyipaddress.com/dhcp>

# How Does The LAN Work

## LAN Frame Transport

1. Device 1 checks if Device 2 IP address is on same network as Device 1 IP address
  - A. If Yes
    - a) Device 1 sends local LAN ARP broadcast message asking for the MAC address of Device 2
    - b) Device 2 responds to Device 1 with its MAC address
    - c) Device 1 uses the MAC address to send frame solely to Device 2
  - B. If No
    - a) Device 1 sends local LAN ARP broadcast asking for the MAC address of the default gateway router
    - b) The gateway router responds to Device 1 with its MAC address
    - c) Device 1 uses the MAC address to send frame to the router
    - d) Etc....

ARP: Address Resolution Protocol

"Cisco Networking Essentials, Second Edition," Troy McMillan, John Wiley & Sons, Inc., 2015

<http://www.erg.abdn.ac.uk/users/gorry/course/inet-pages/arp.html>

[https://en.wikipedia.org/wiki/Address\\_Resolution\\_Protocol#Packet\\_structure](https://en.wikipedia.org/wiki/Address_Resolution_Protocol#Packet_structure)



# How Does The LAN Work

## LAN Frame Transport

1. Device 1 checks if Device 2 IP address is on same network as Device 1 IP address

A. If Yes

- a) Device 1 sends local LAN ARP broadcast message asking for the MAC address of Device 2
- b) Device 2 responds to Device 1 with its MAC address
- c) Device 1 uses the MAC address to send frame solely to Device 2

B. If No

- a) Device 1 sends local LAN ARP broadcast message asking for the MAC address of the default gateway
- b) The gateway responds to Device 1 with its MAC address
- c) Device 1 sends frame to gateway
- d) Etc.

ARP Request Message: Who is ip 192.168.1.159 tell ip 192.168.1.5  
Message uses MAC broadcast address as the target address and its own MAC source address

ARP: Address Resolution Protocol

"Cisco Networking Essentials, Second Edition, by John W. Doolittle, John Wiley & Sons, Inc., 2015

<http://www.erg.abdn.ac.uk/users/gorry/course/inet-pages/arp.html>

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# How Does The LAN Work

## LAN Frame Transport

1. Device 1 checks if Device 2 IP address is on same network as its own IP address

A.

ARP Response Message from 192.168.1.159 :  
192.168.1.159 is MAC address 23:F2:AB:61:4C:3D  
Responder uses 192.168.1.5 MAC as the target address  
and its own MAC source address

B. If No

- a) Device 1 sends local LAN ARP broadcast to all devices on the LAN with the IP address of the default gateway.
- b) The gateway responds with its own MAC address.
- c) Device 1 then sends the packet to the gateway.
- d) Etc.

ARP Request Message: Who is ip 192.168.1.159 tell ip 192.168.1.5  
Message uses MAC broadcast address as the target address and its own MAC source address

# WiFi

U.S. Bands	2.4 GHz	5 GHz
Range - Indoors	~ 150 feet	~ 50 feet
Range - Outdoors	~ 300 feet	~ 100 feet
Max Speed 802.11n		300 Mbps <sup>1</sup>
Typical Speed 802.11n		<< 300 Mbps <sup>2</sup>

<http://www.everymac.com/systems/apple/apple-tv/apple-tv-faq/what-is-802.11n-differences-between-802.11n-802.11a-802.11b-802.11g.html>  
<https://www.lifewire.com/range-of-typical-wifi-network-816564>

1: With lots of caveats

2: Speed dependant on obstacles, distance, WiFi multi-users, multipath-fading, interfering signals, ISP service speed & load

# 802.11

Standard	Max Speed	Throughput	Frequency	Range
802.11a	54 Mbps	22 Mbps	5 GHz	150 feet
802.11b	11 Mbps	6 Mbps	2.4 GHz	300 feet
802.11g	54 Mbps	22 Mbps	2.4 GHz	300 feet
802.11n	248 Mbps	74 Mbps	2.4/5 GHz	230 feet
802.11ac	1300 Mbps		5 GHz	230 feet

US 2.4 GHz band: 11 20-MHz channels, maximum of 3 non-overlapping channels

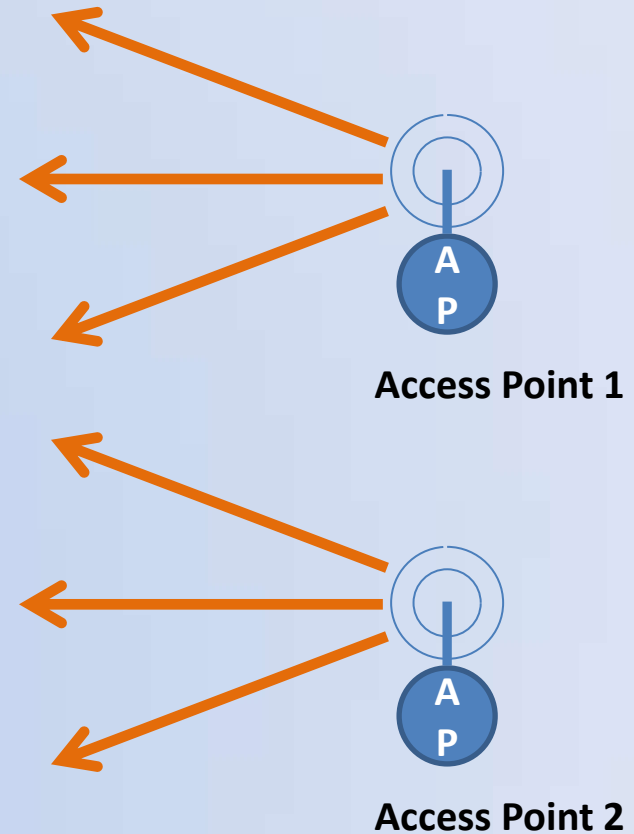
US 5 GHz Band: 8 20-MHz channels with 2/4-channel bonding possible

# WiFi Setup

## Access Point (AP) Beacon



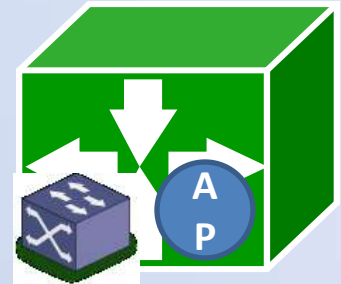
- Beacon** (at 100 ms intervals)  
Uses Ethernet headers (MAC address)  
Contains:
- Timestamp
  - SSID (WiFi network name)
  - Supported data rates
  - Radio parameters
  - Encryptions details



# WiFi Setup



You



Home router  
(Access Point)

← Beacon (SSID, channels/a-b-g-n, encryption types, MAC address)

→ Authentication request (target AP MAC address & SSID, open or encryption)

← Authentication response (accept/reject)

→ Association request (target SSID, capabilities, rates)

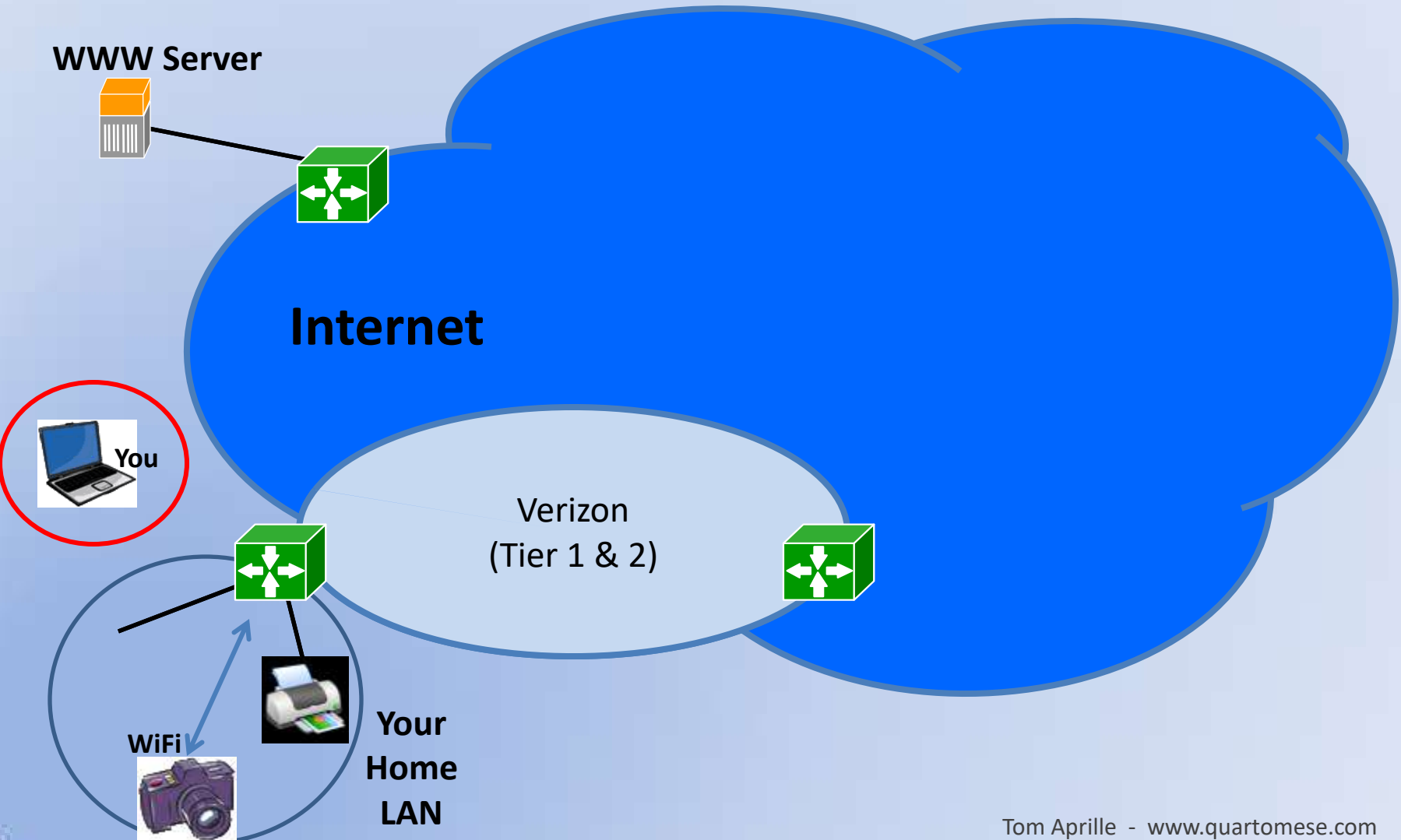
← Association response (association ID, initial parameters)

← Data

How Does It  
All Work Together  
In The Beginning ...

# Connecting To The Network

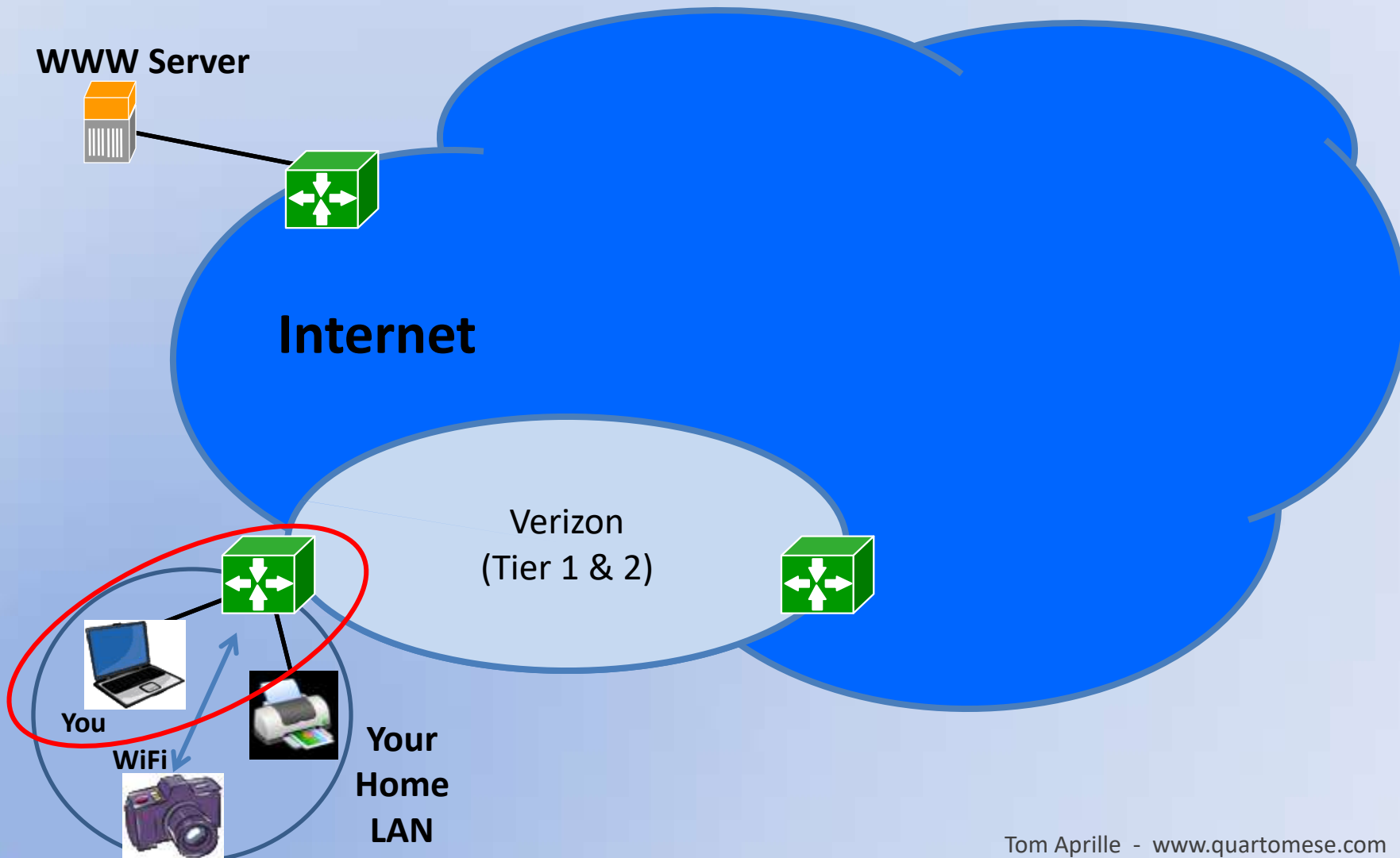
**Not** Connected





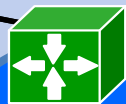
# Connecting To The Network

~~Not~~ Connected



# Connecting To The Network Hand-Shake

WWW Server



Internet

Router & PC NIC cards recognized - green light  
- Via NIC card link layer keep alive signals  
PC NIC broadcasts DHCP "discover" message onto the LAN  
- Who has the DHCP server ?  
- Somebody give me an IP address !!  
The DHCP server in most all cases is "your" home router

Verizon  
(Tier 1 & 2)



You



WiFi

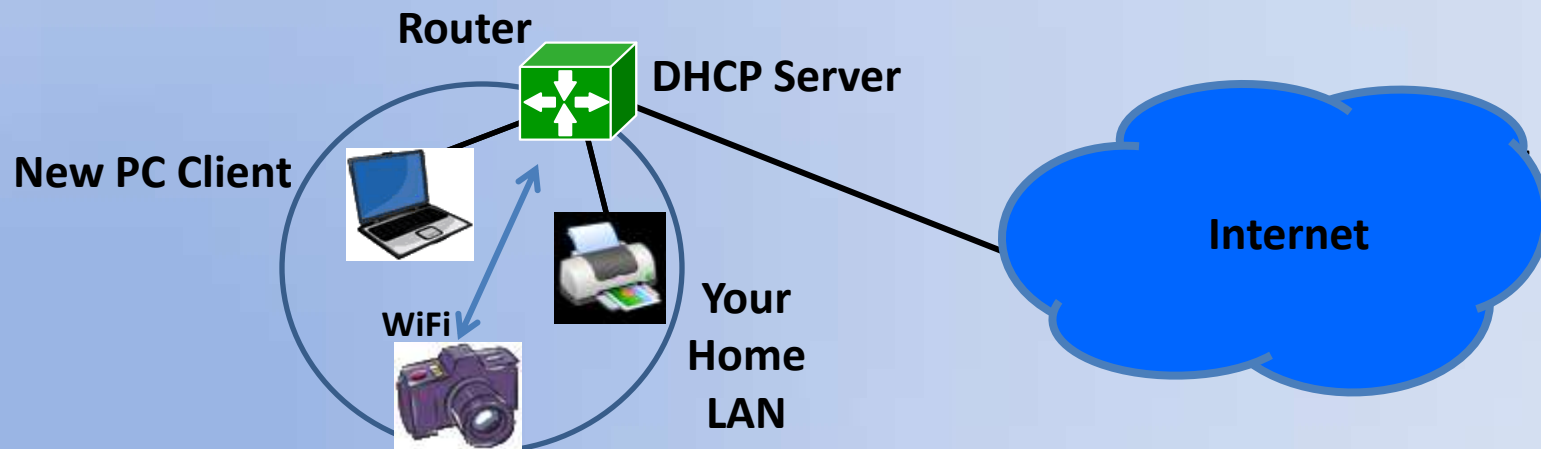


Your  
Home  
LAN



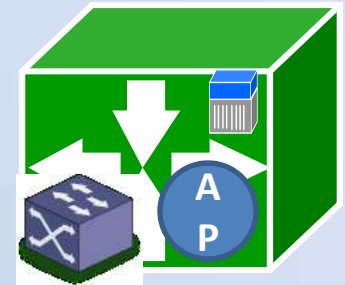
# Dynamic Host Configuration Protocol

Source MAC Address	Source IP Address	Destination MAC Address	Destination IP Address	Transaction ID	DHCP Message Type	Function
PC Client	0 . 0 . 0 . 0	Broadcast	255.255.255.255	0x123	DHCP Discover	DHCP Available - I need an IP Address
DHCP Server	DHCP Server	Broadcast	255.255.255.255	0x123	DHCP Offer	How about 192.168.1.8
PC Client	0 . 0 . 0 . 0	Broadcast	255.255.255.255	0x123	DHCP Request	I agree to take 192.168.1.8
DHCP Server	DHCP Server	Broadcast	255.255.255.255	0x123	DHCP ACK	It's yours - goodbye



# ISP Supplied Network Router

- Interconnects two networks
  - Your LAN network and the ISP network
- 4 - 8 port Ethernet switch
- Integrated WiFi Access Point (AP)
- Network Address Translator (NAT)
  - Multiple IP Hosts to 1 IP Address, Port Forwarding
- Routing table
- DHCP server
- DNS name server
- Gateway router function
- Firewall



Home router



AP: Access Point

NAT: Network Address Translator

DHCP: Dynamic Host Configuration Protocol

DNS: Domain Name System

# *In Summary*

# High-Level Internet Architecture

- There are four major IP Networking components
  - Hosts (client computers and server computers)
    - Hosts exchange application data via IP packets
  - Routers
    - Routers point IP packets to the next hop Router/Host
  - LAN/WAN
    - Between a Router/Host and a Router/Host there is a LAN or WAN
      - A LAN/WAN encapsulates the IP packet in a “frame format”
      - LAN/WAN physically transport frames to and from routers and hosts

This talk can be found at:  
<http://quartomese.com/talks/talks.php>

The End