Network Security: Background

CS 161: Computer Security

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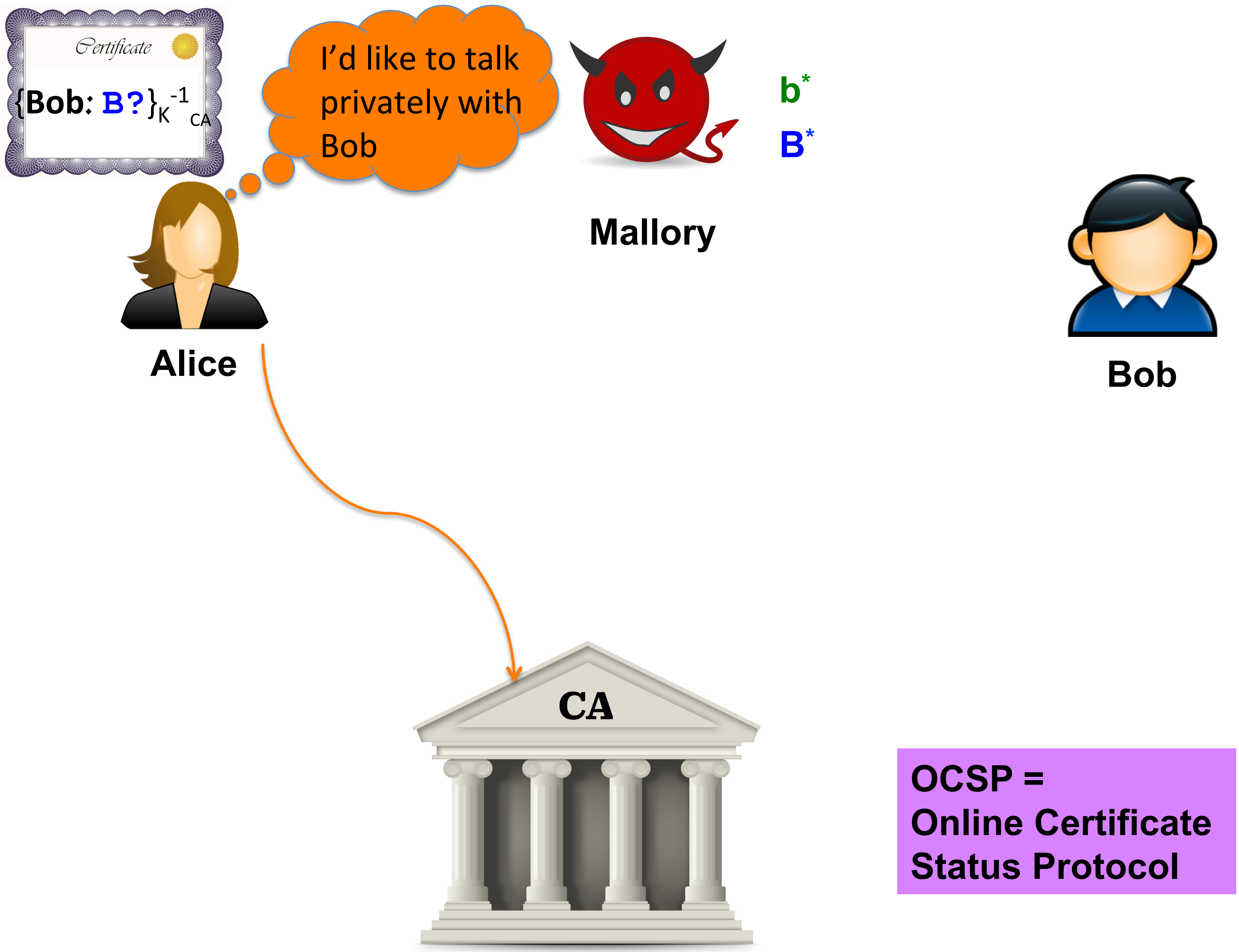
March 7, 2017

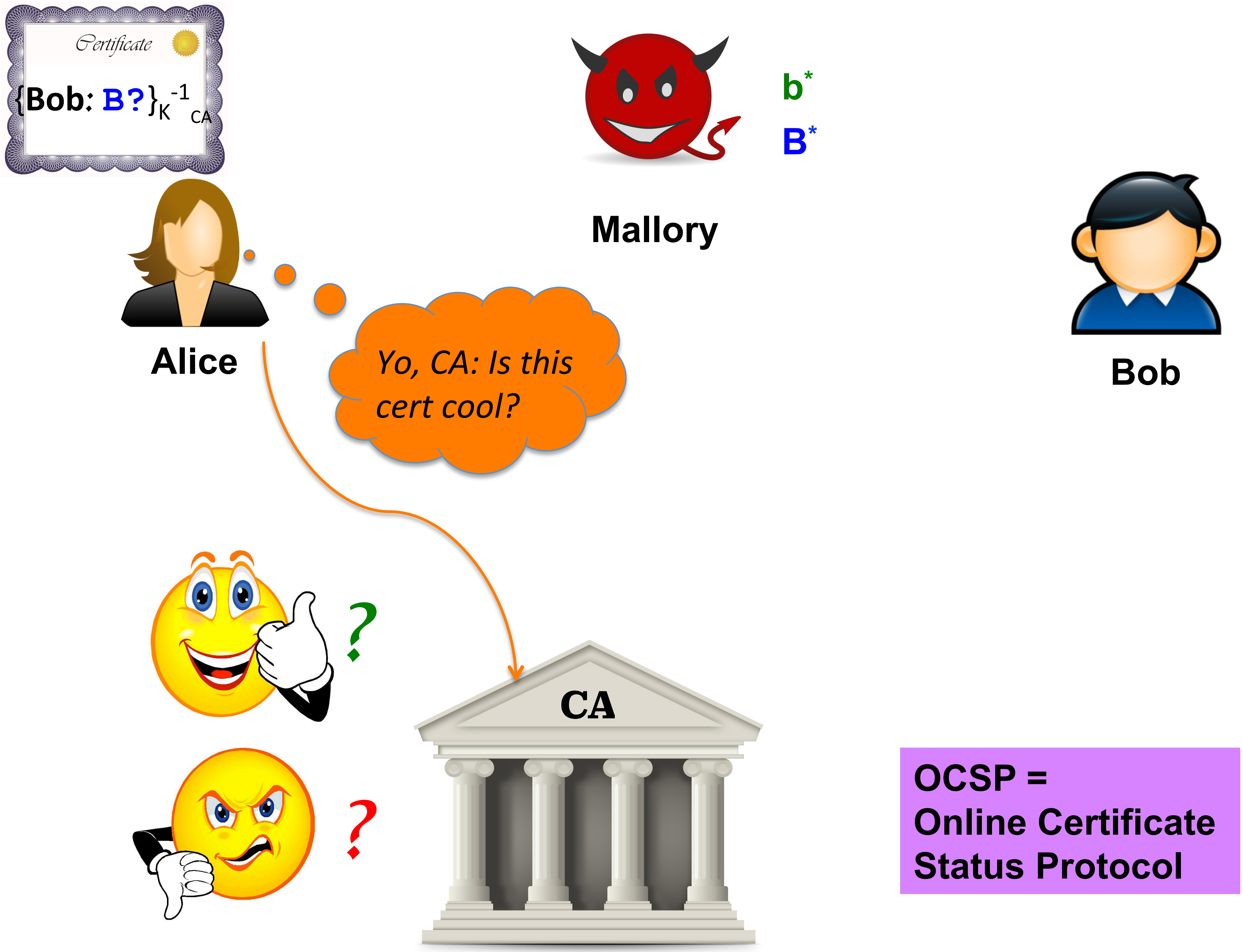
Revocation, con't

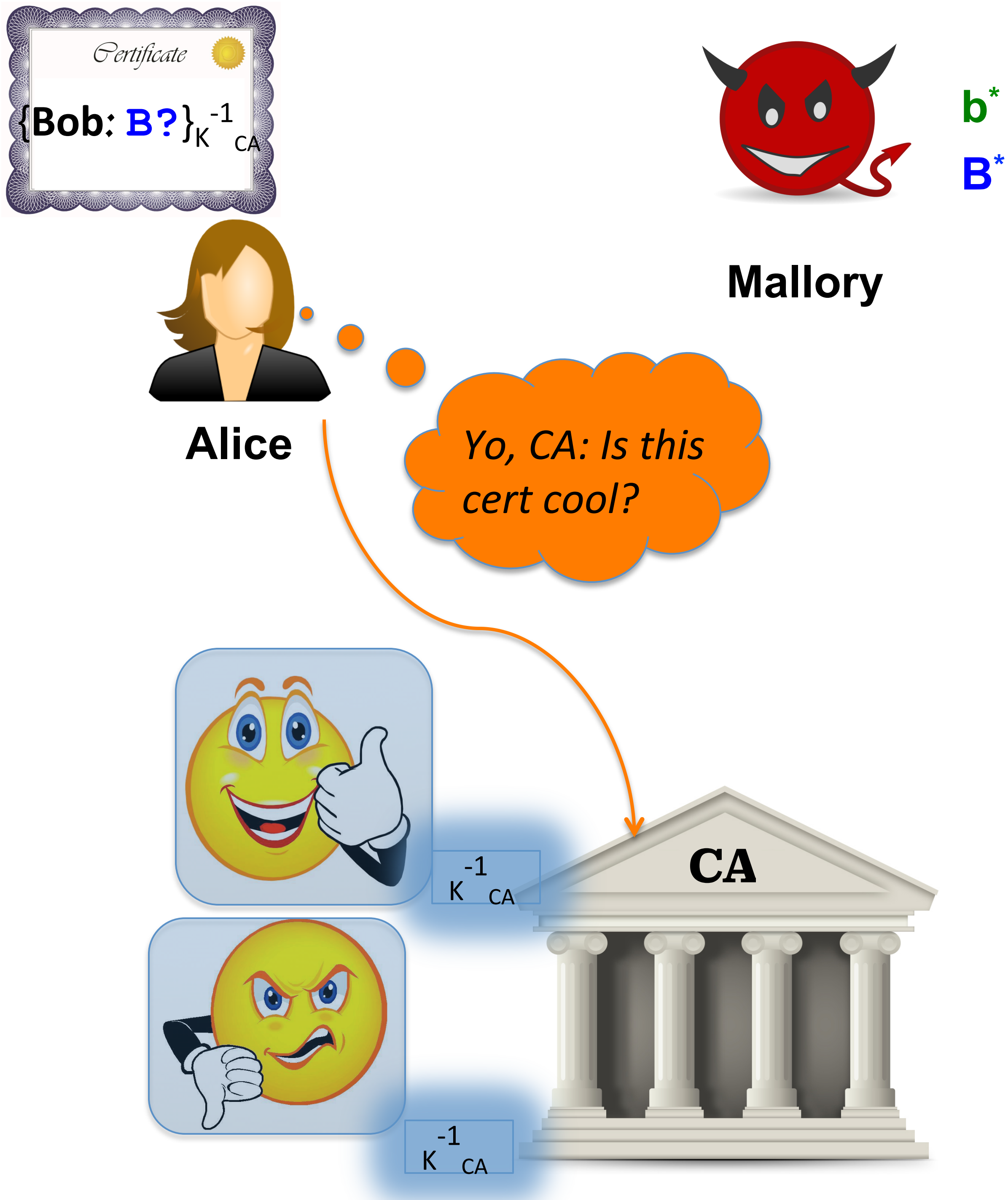
- Approach #2: announce revoked certs
  - Users periodically download *cert revocation list* (CRL)
- Issues?
  - Lists can get large
  - Need to *authenticate the list* itself – how? Sign it!
  - Mallory can exploit download lag
  - What does Alice do if can't reach CA for download?
    1. Assume all certs are invalid (*fail-safe defaults*)
       - Wow, what an unhappy failure mode!
    2. Use old list: widens exploitation window if Mallory can "DoS" CA (DoS = denial-of-service)

Revocation, con't

- Approach #3: CA provides service to query
  - OCSP: *Online Certificate Status Protocol*


Certificate
{Bob: B?}$_{K^{-1}_{CA}}$
I'd like to talk privately with Bob
Mallory
b*
B*
Alice
Bob
CA
OCSP =
Online Certificate Status Protocol


Certificate
{Bob: B?}$_{K^{-1}_{CA}}$
Mallory
b*
B*
Alice
Yo, CA: Is this cert cool?
Bob
?
?
CA
OCSP =
Online Certificate
Status Protocol

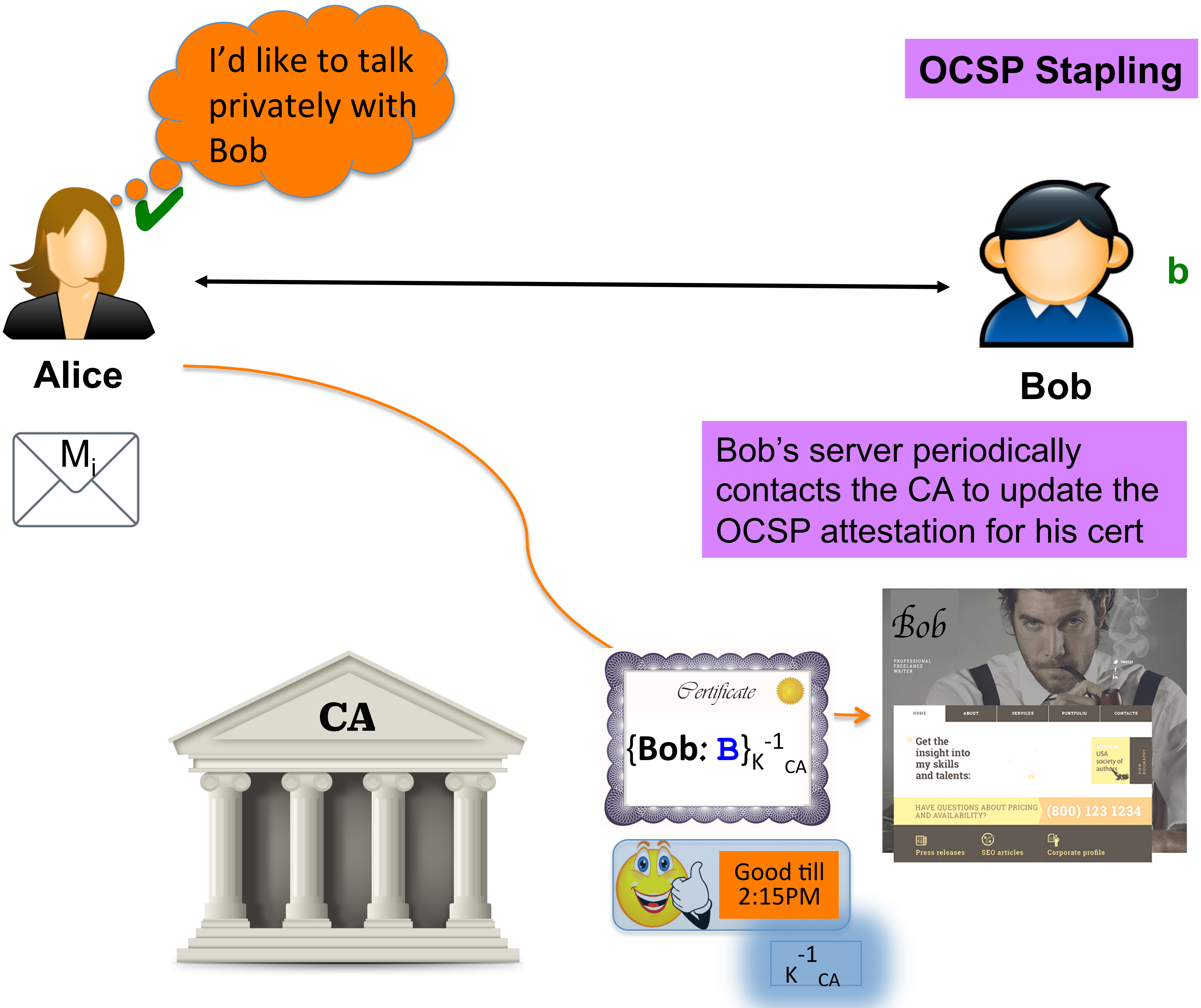


OCSP =
Online Certificate Status Protocol

Revocation, con't

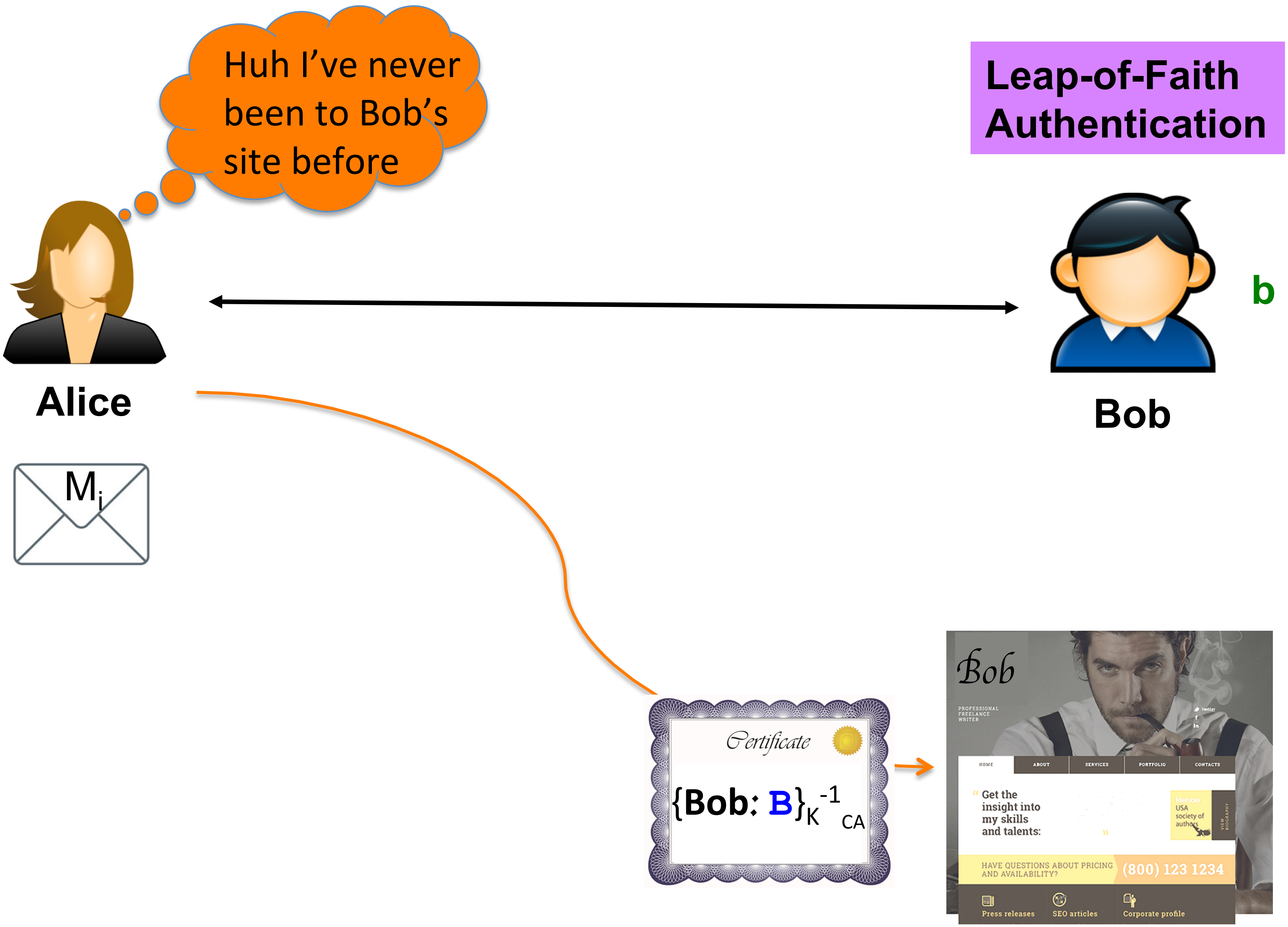
- Approach #3: CA provides service to query
  - OCSP: *Online Certificate Status Protocol*

- Issues?
  - Can't be used if Alice doesn't have connectivity to CA
  - CA learns that Alice talks to Bob
  - CA had better build this in a scalable fashion!
  - CA outages ⇒ big headaches
    - OR: Alice defaults to trusting if OCSP inaccessible
      - Again creates a DoS threat


OCSP Stapling
I'd like to talk privately with Bob
Alice
Bob
b
M_i
Bob's server periodically contacts the CA to update the OCSP attestation for his cert
CA
Certificate
{Bob: B}K-1CA
Good till 2:15PM
K-1CA
Bob
PROFESSIONAL FREELANCE WRITER
HOME
ABOUT
SERVICES
PORTFOLIO
CONTACTS
Get the insight into my skills and talents:
HAVE QUESTIONS ABOUT PRICING AND AVAILABILITY?
(800) 123 1234
Press releases
SEO articles
Corporate profile

Leap-of-Faith Authentication

- A completely different approach leverages key continuity



Leap-of-Faith Authentication
Huh I've never been to Bob's site before
Alice
Bob
b
M_i
Certificate
$\{Bob: B\}_{K^{-1}_{CA}}$
Bob
PROFESSIONAL FREELANCE WRITER
Get the insight into my skills and talents:
HAVE QUESTIONS ABOUT PRICING AND AVAILABILITY?
(800) 123 1234
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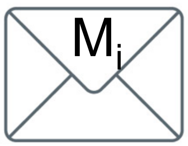
Leap-of-Faith Authentication

Alice

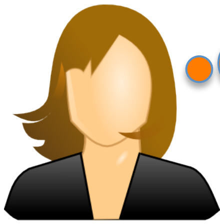
I'm going to **hope** that ***just** this one time*, Mallory didn't show up …

b

Bob



Leap-of-Faith Authentication

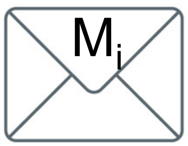


But **now that I have the cert**, any time in the future I'll *refuse a different cert* if offered

b

Alice

Bob



Leap-of-Faith Authentication, con't

- A completely different approach leverages key continuity
  - Also called TOFU: *Trust On First Use*
  - A form of "pinning"
    - Require cert to have specific properties, like particular CA
  - Very popular for SSH
    - Web browsers don't expose an easy equivalent usage model

Leap-of-Faith Authentication, con't

- Properties/Issues?

- Doesn't bug you, just automatically gives you a secure mode of operation
  - Great design property!
- Leverages mental expectations
  - Such as: "hard for attacker to anticipate this'll be my very first visit" (clearly not always true!)
  - Or: "Bob mentioned he'd be upgrading, so the new key is expected"
- Brittle: relies on user to notice and *thoughtfully respond* to key changes

Background on Networking

Network Security

- Why study network security?
  - Networking greatly extends our overall attack surface
    - Networking = the Internet
  - Opportunity to see *how large-scale design affects security issues*
  - Protocols a great example of *mindless agents* in action
- This lecture: sufficient background in networking to then explore security issues in next ~5 lectures
- Complex topic with many facets
  - We will omit concepts/details that aren't very security-relevant
  - By all means, ask questions when things are unclear
    - (but we may skip if not ultimately relevant for security, or postpone if question itself is directly about security)

Protocols

- A protocol is an agreement on how to communicate
- Includes syntax and semantics
  - How a communication is specified & structured
    - Format, order messages are sent and received
  - What a communication means
    - Actions taken when transmitting, receiving, or timer expires
- E.g.: making a comment in lecture?
  1. Raise your hand.
  2. Wait to be called on.
  3. Or: wait for speaker to **pause** and vocalize
  4. If unrecognized (after timeout): vocalize w/ “excuse me”

So You Walk Into A Coffee Shop,

Open Up Your Laptop,

And Issue a Google Query ….

Coffee Shop

Coffee Shop

1. Join the wireless network

Your laptop shouts:
HEY, DOES WIRELESS NETWORK X EXIST?

Coffee Shop

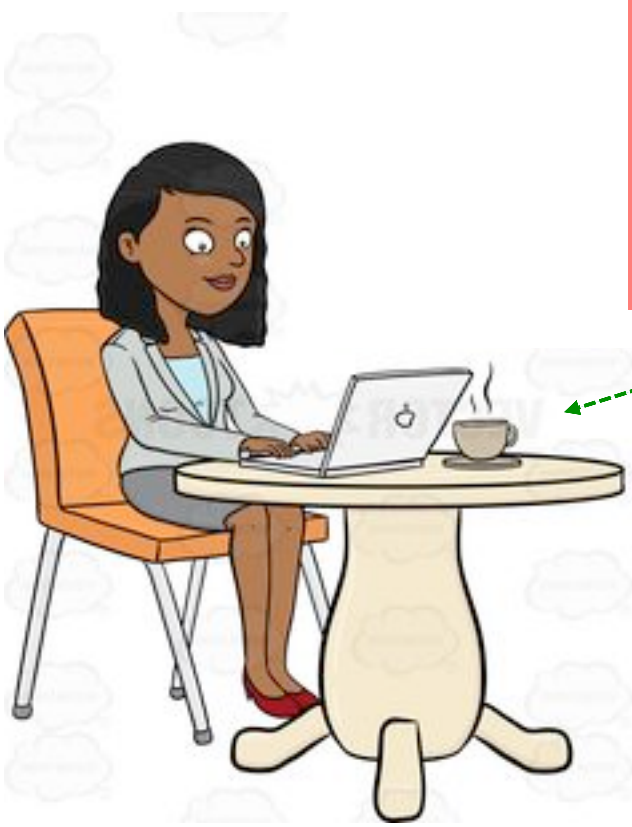
1. Join the wireless network

Wireless access point(s) continually shout:
HEY, I'M WIRELESS NETWORK Y, JOIN ME!

Coffee Shop

1. Join the wireless network

If either match up, your laptop joins the network. Optionally performs a cryptographic exchange.



Coffee Shop

2. Configure your connection

Coffee Shop

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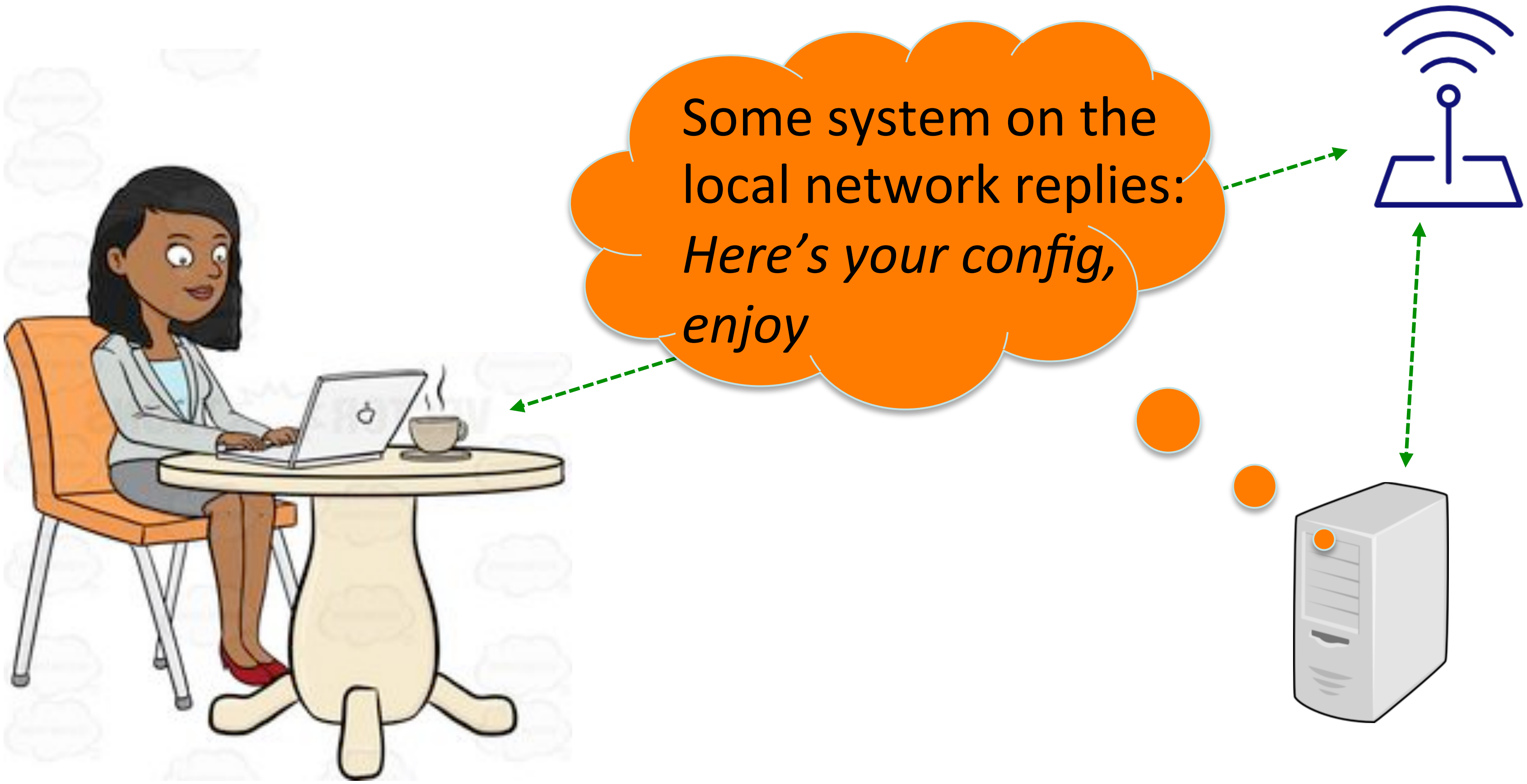
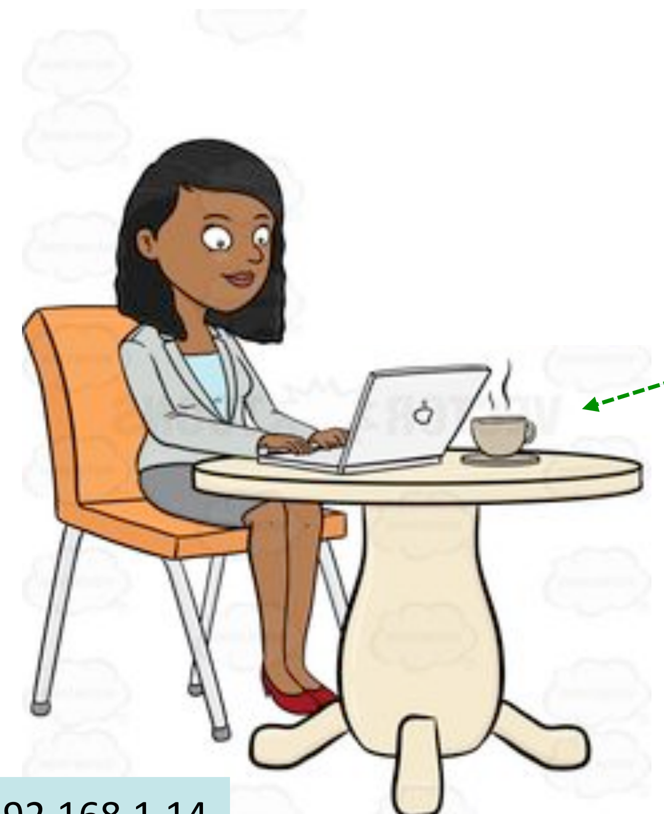


Coffee Shop

2. Configure your connection

The configuration includes:

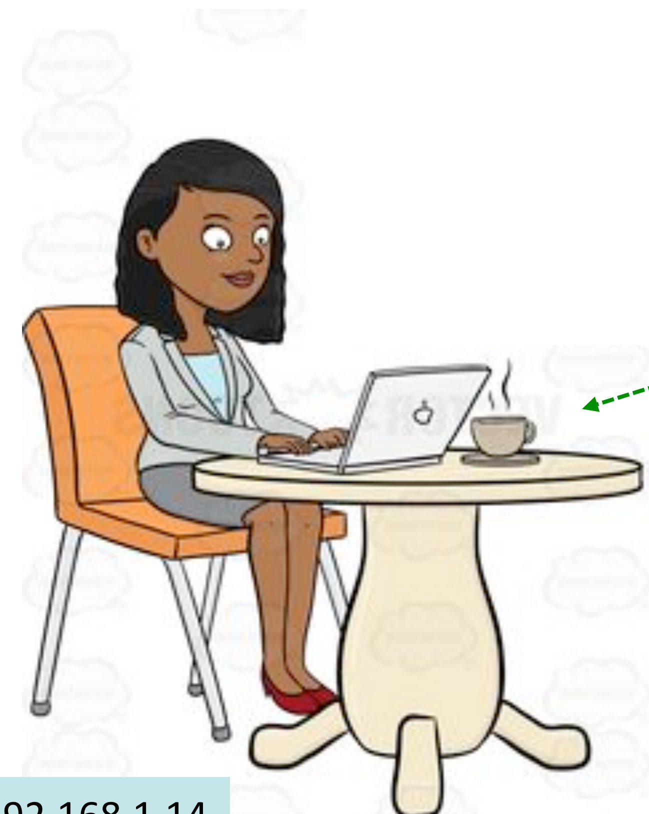
(1) An Internet address (**IP address**) your laptop should use; typ. 32 bits
(2) The address of a "**gateway**" system to use to access *hosts* beyond the local network
(3) The address of a **DNS server** ("*resolver*") to map names like `google.com` to IP addresses



192.168.1.14

Coffee Shop

3. Find the address of google.com

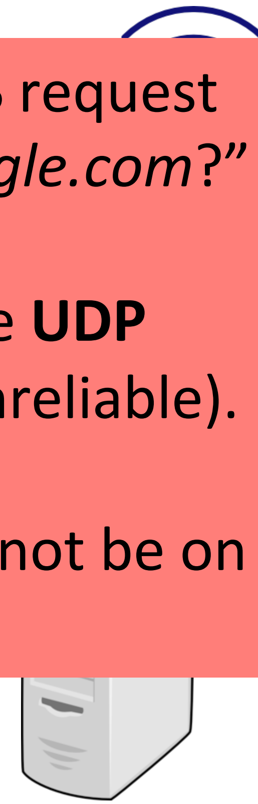


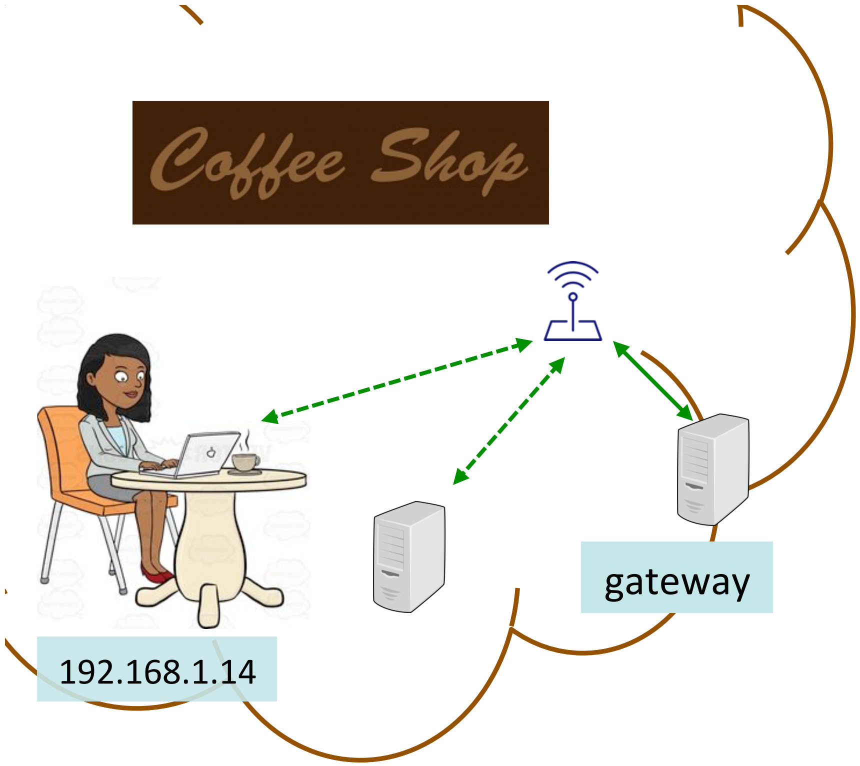
192.168.1.14

Your laptop sends a **DNS** request asking: “*address for google.com*?”

It’s transmitted using the **UDP** protocol (lightweight, unreliable).

The DNS **resolver** might not be on the local network.





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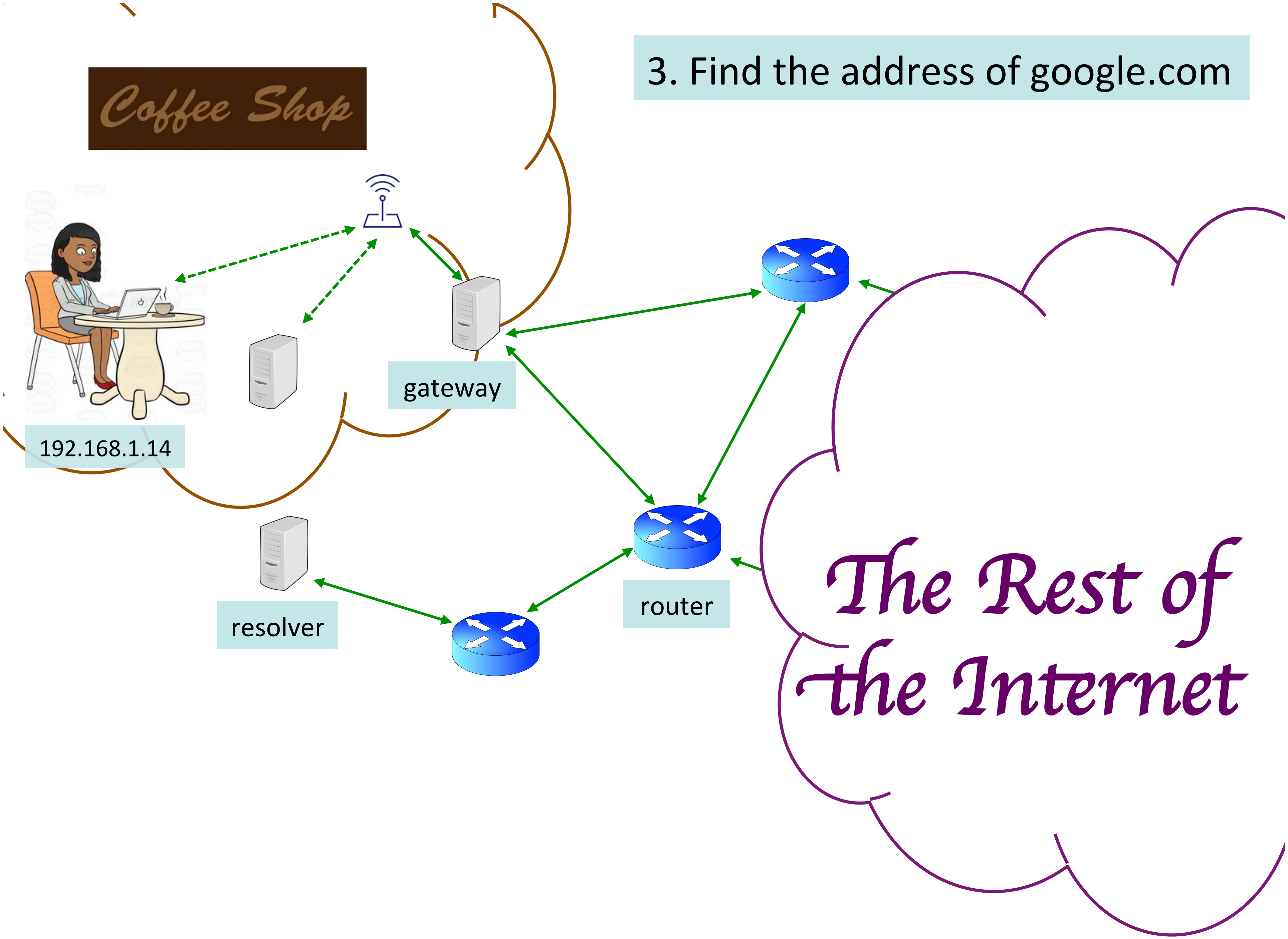
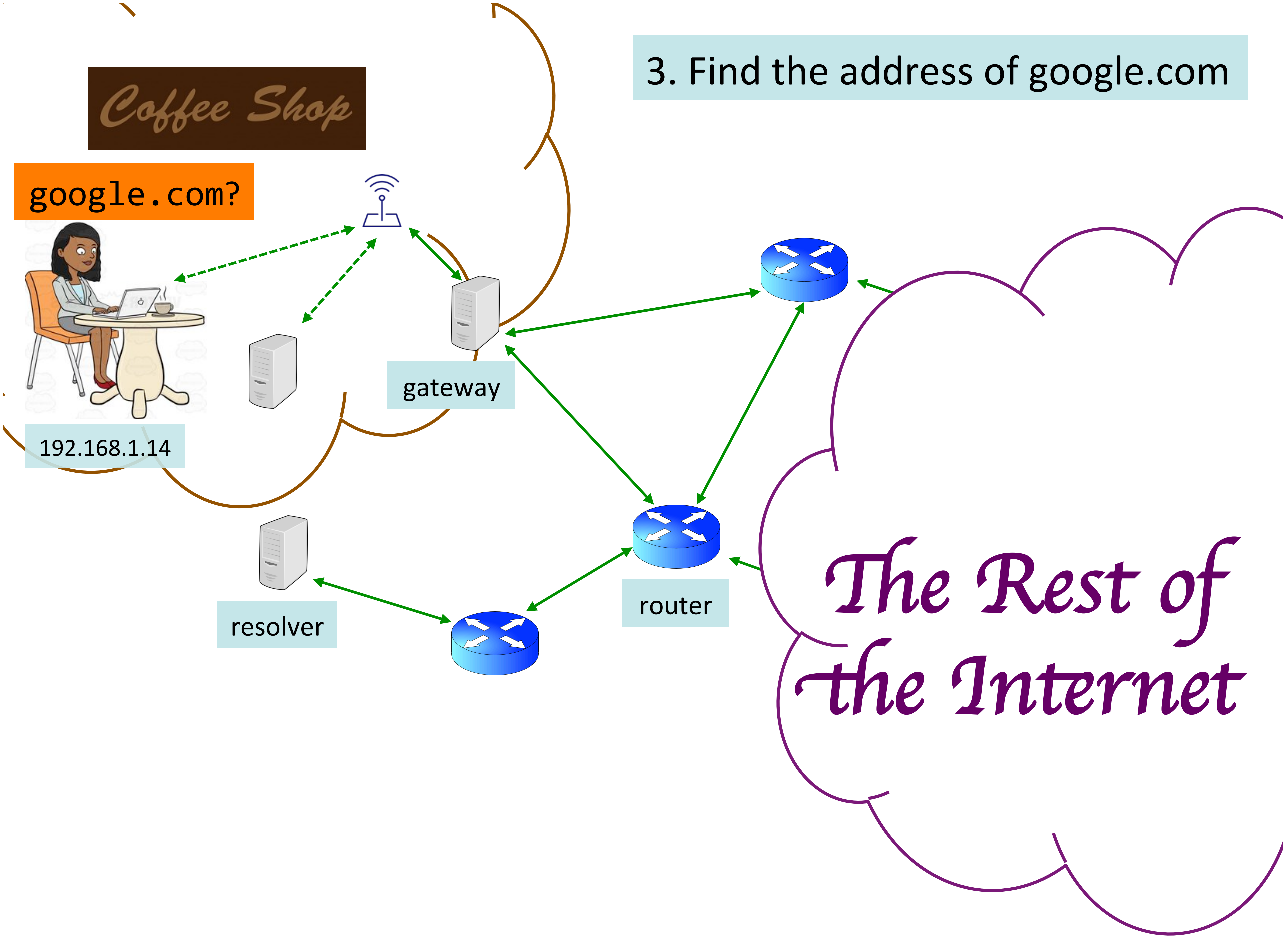


Coffee Shop
3. Find the address of google.com
gateway
192.168.1.14
resolver
router
The Rest of the Internet

3. Find the address of google.com



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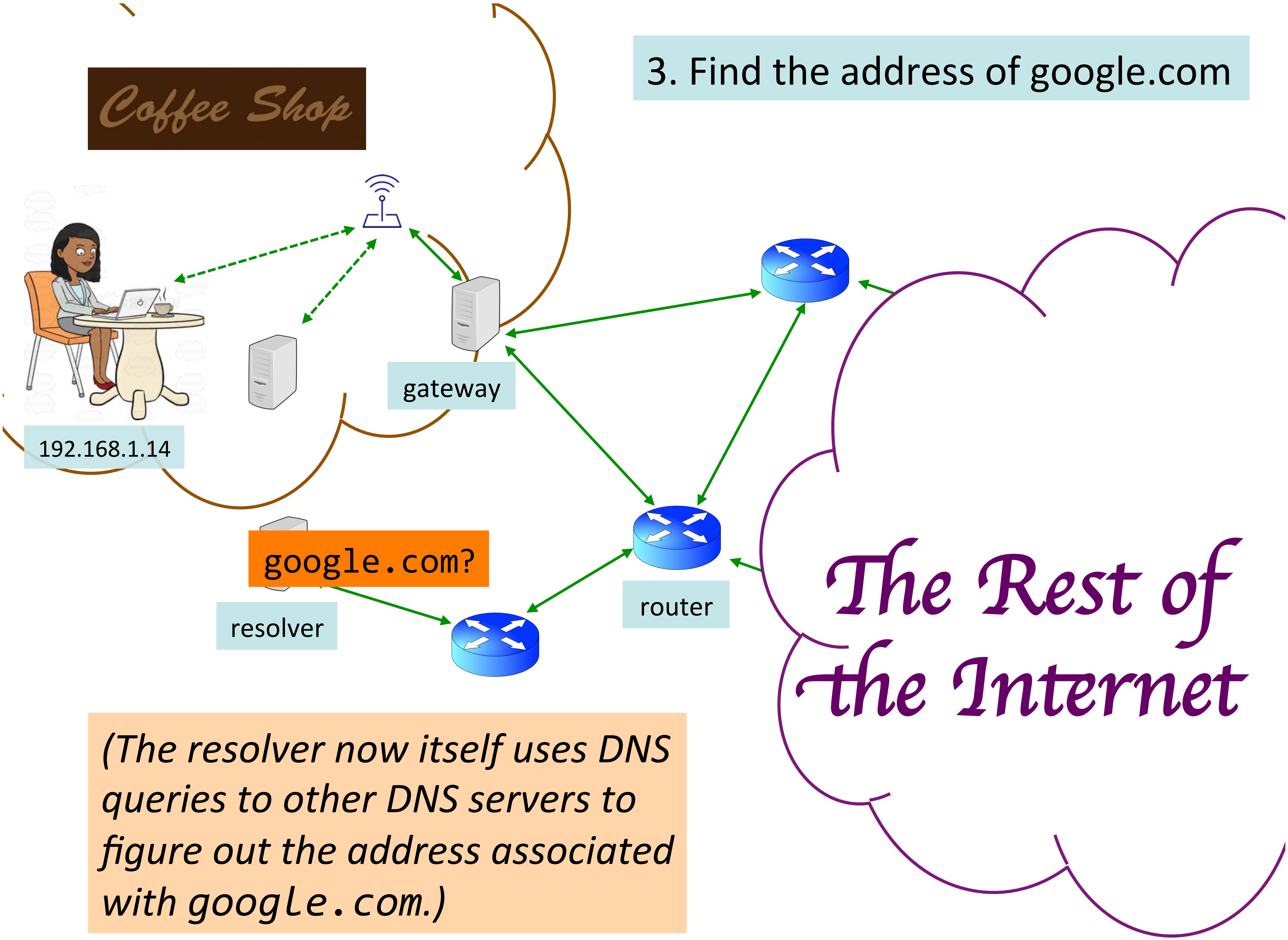
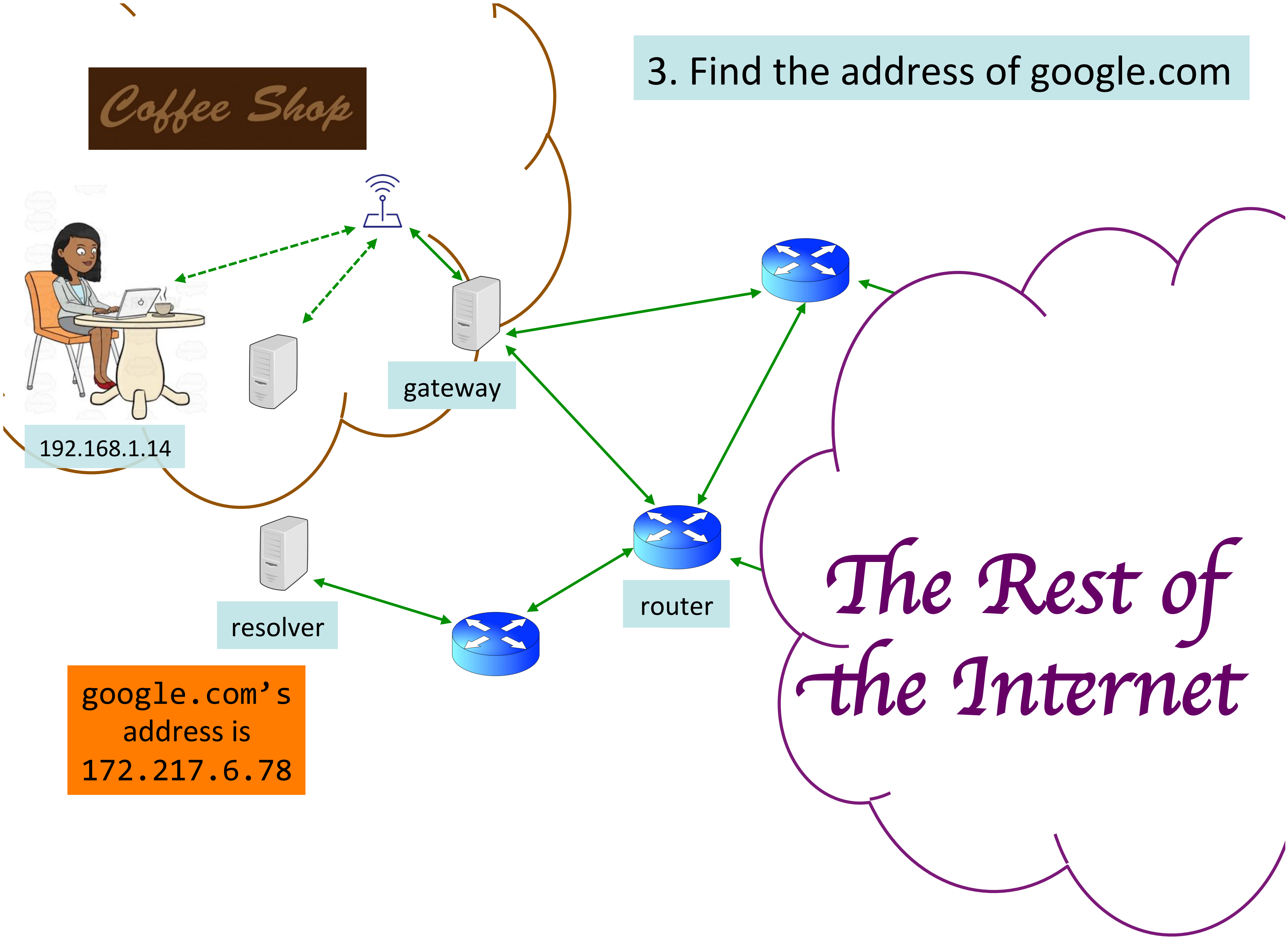
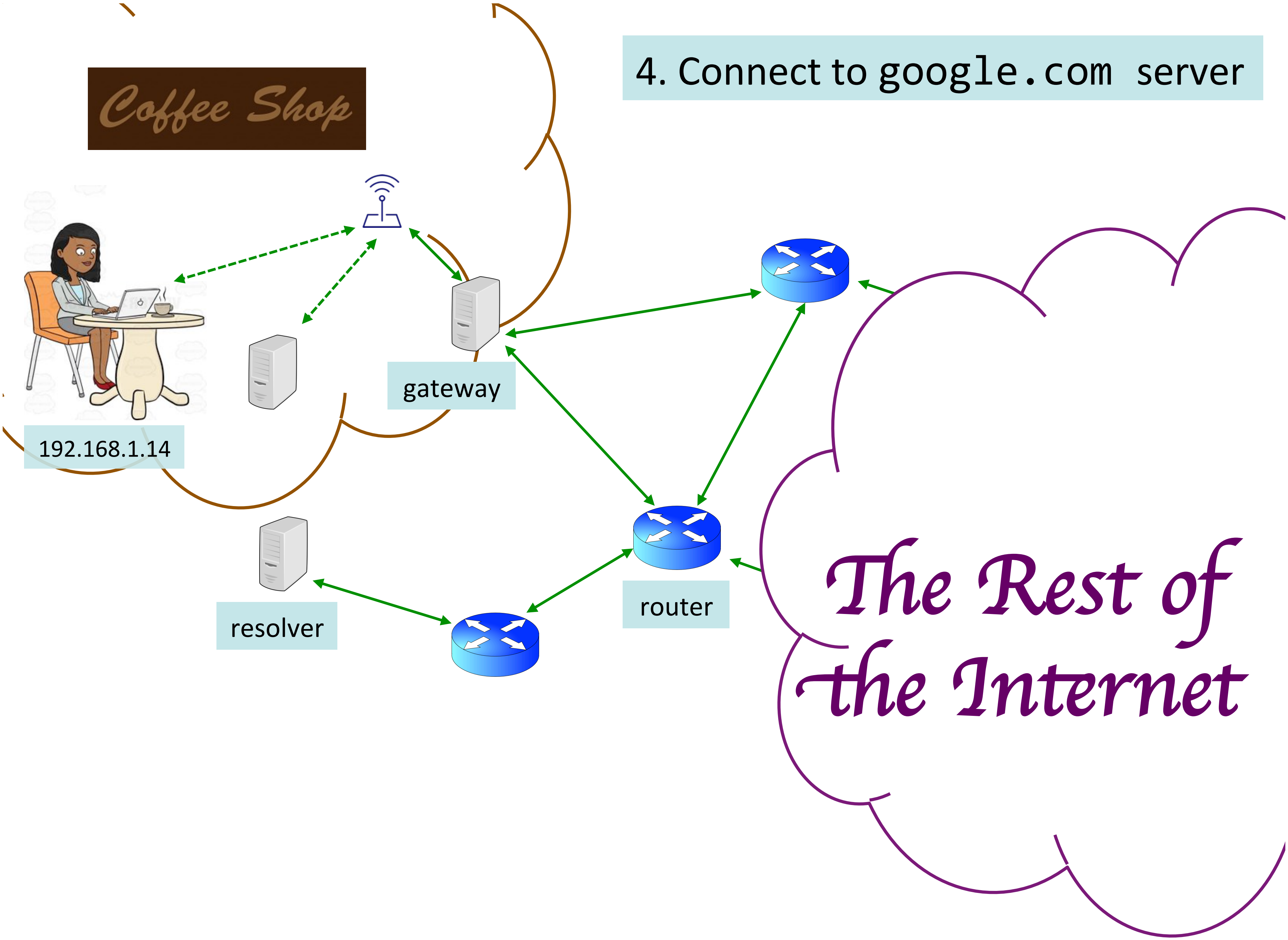


(The resolver now itself uses DNS queries to other DNS servers to figure out the address associated with `google.com`.)

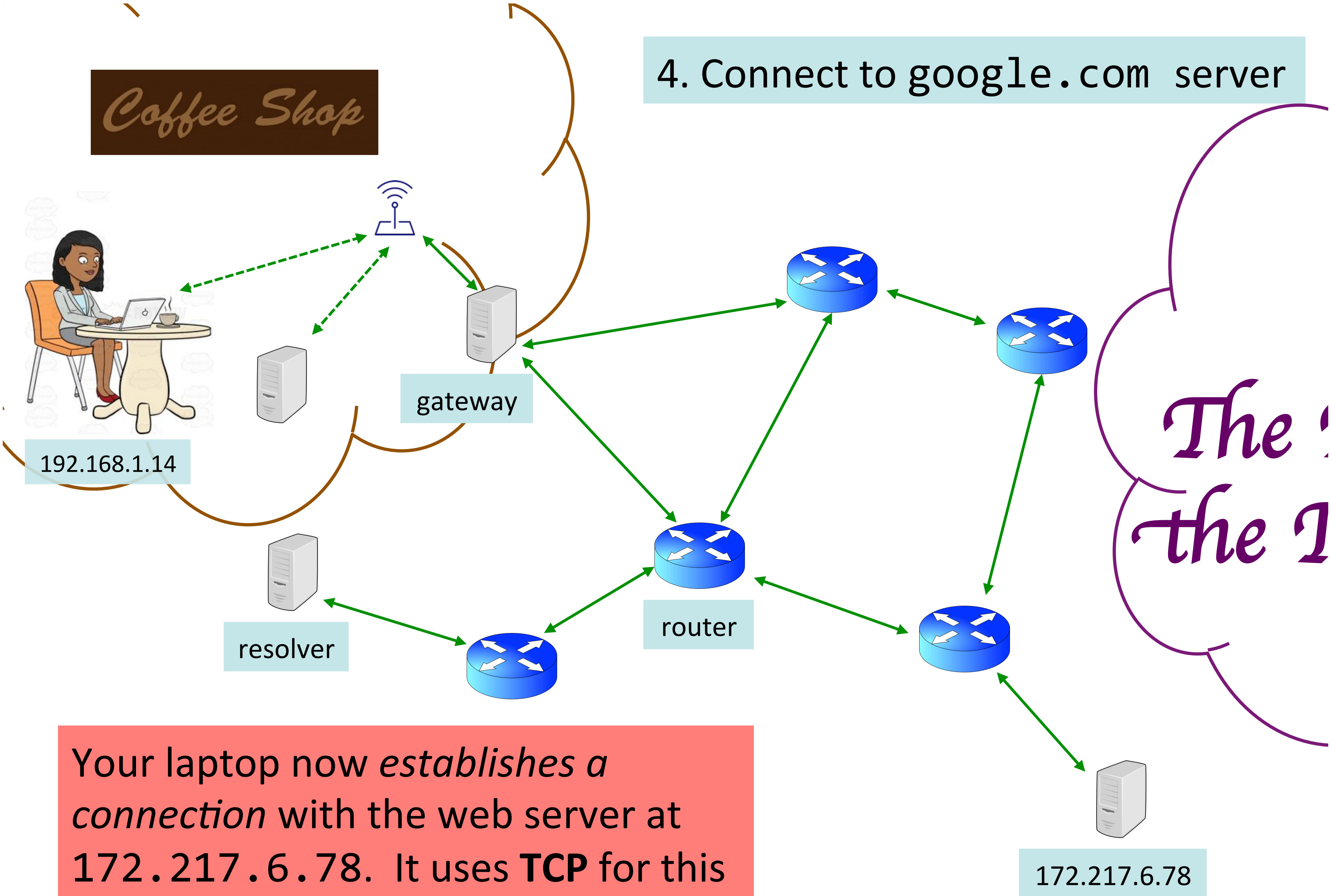
3. Find the address of google.com



4. Connect to google.com server

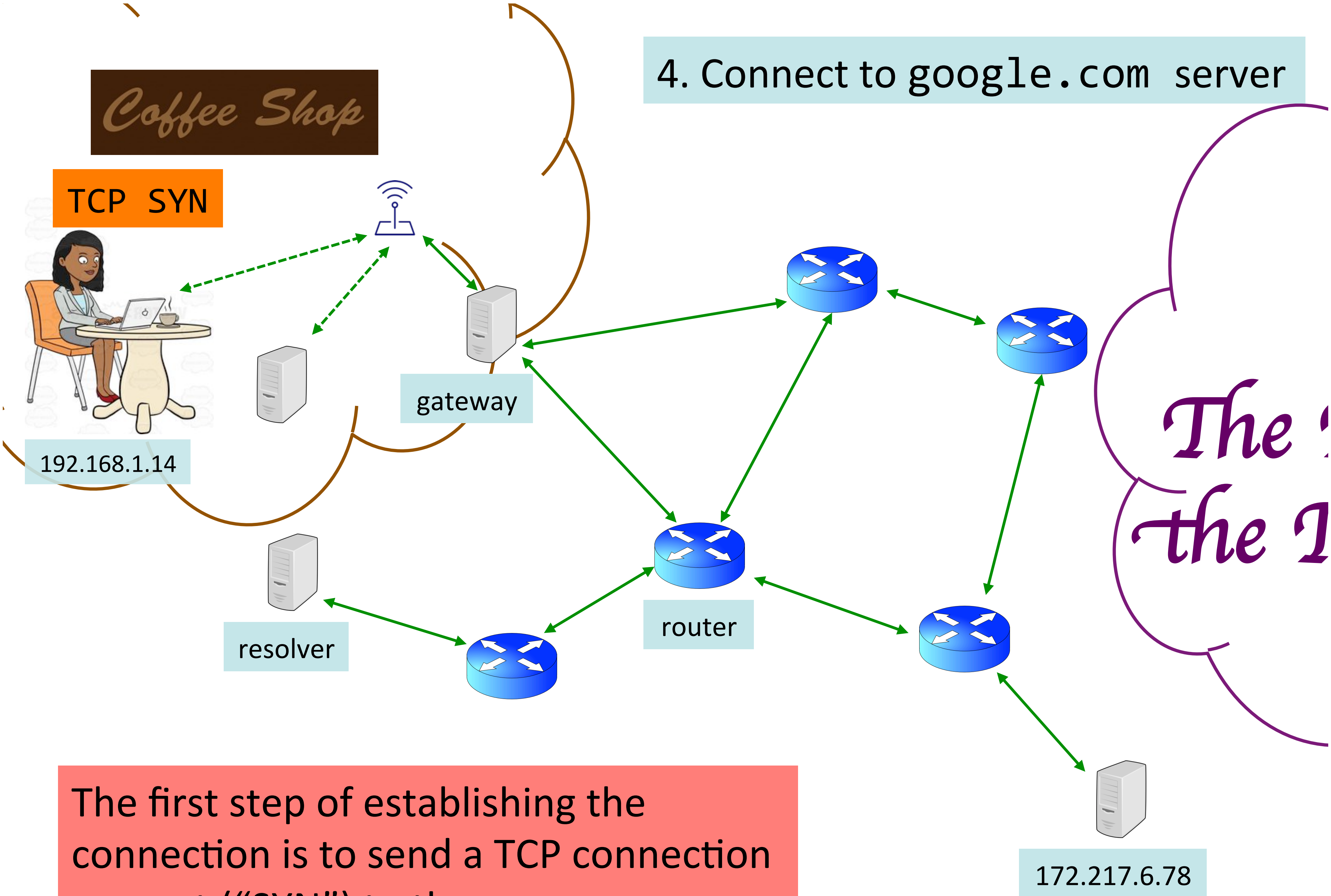


4. Connect to `google.com` server



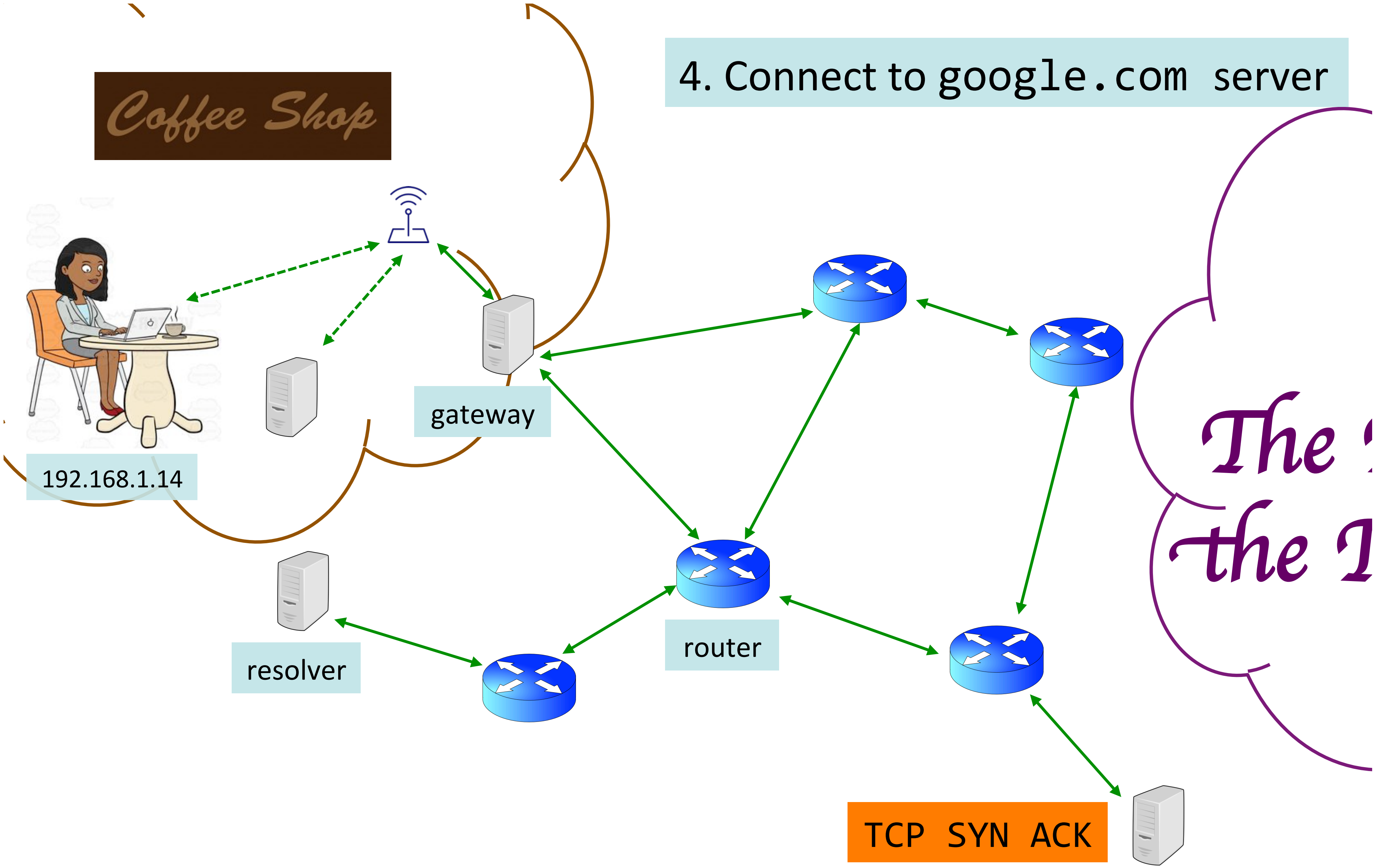
Your laptop now *establishes a connection* with the web server at `172.217.6.78`. It uses **TCP** for this rather than UDP, to obtain reliability.

4. Connect to `google.com` server



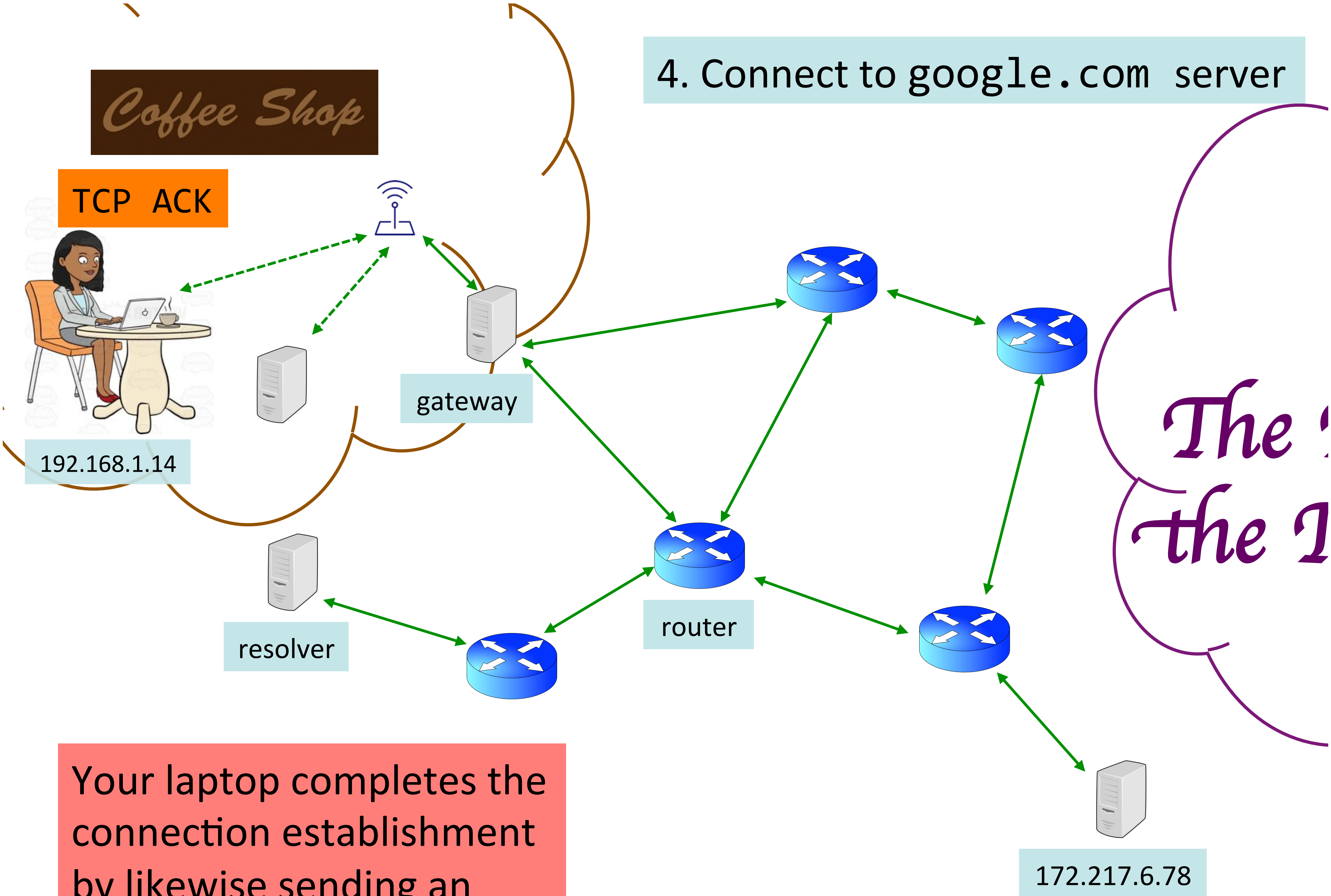
The first step of establishing the connection is to send a TCP connection request ("SYN") to the server.

4. Connect to `google.com` server



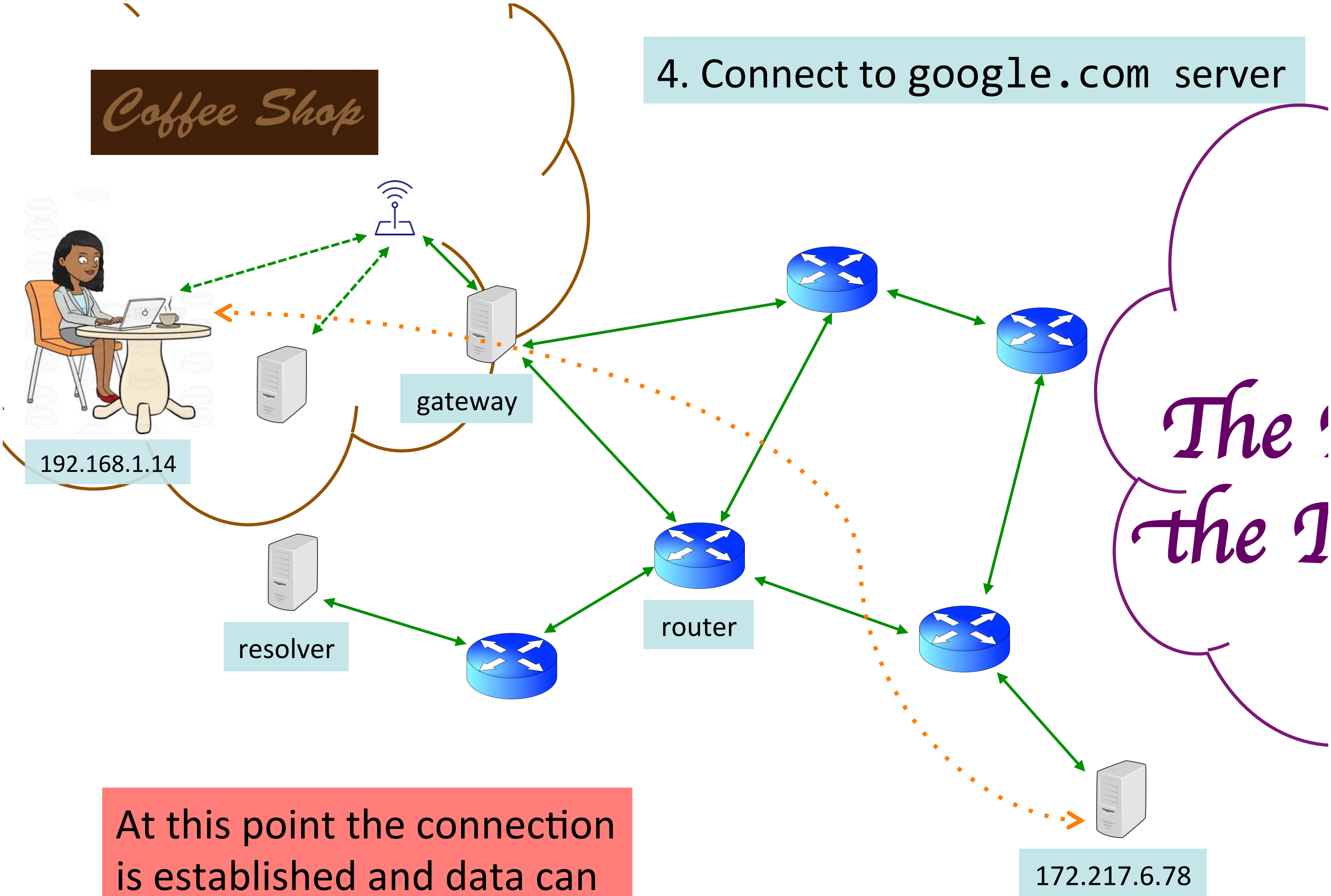
If the server accepts the connection, it replies with a “SYN ACK”.

4. Connect to google.com server

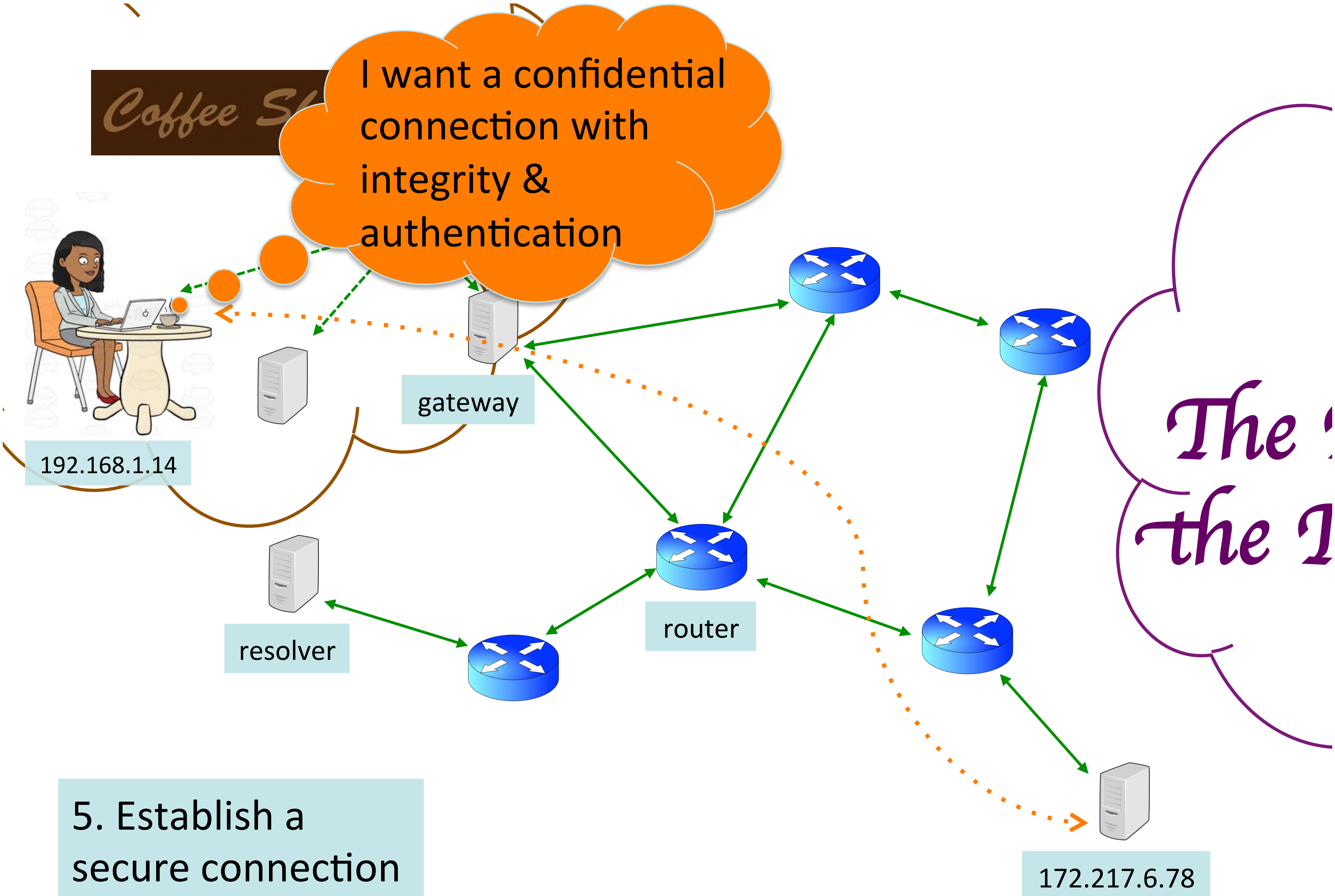


Your laptop completes the connection establishment by likewise sending an acknowledgement.

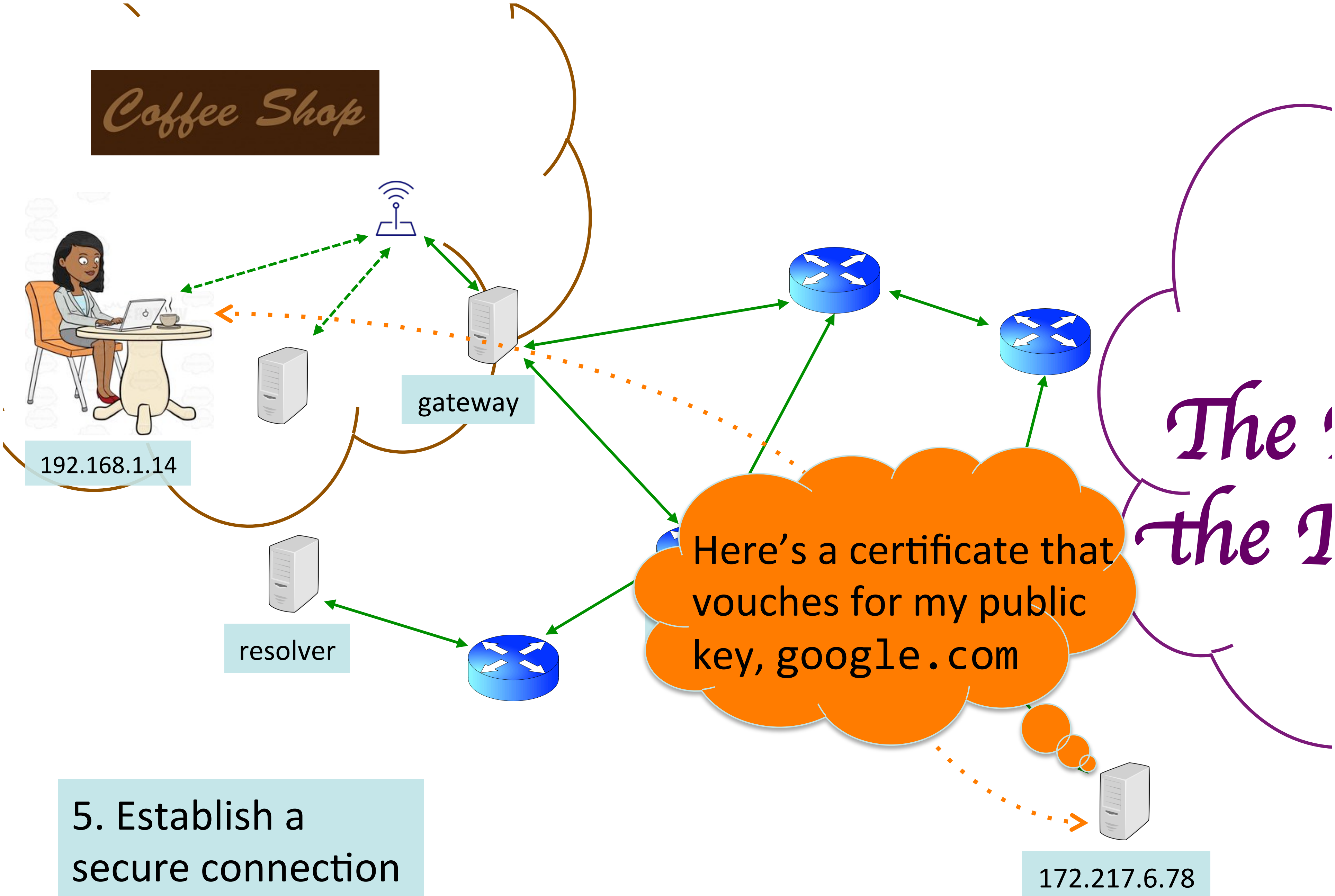
4. Connect to `google.com` server



At this point the connection is established and data can be (reliably) exchanged.



5. Establish a secure connection using **TLS** (https)



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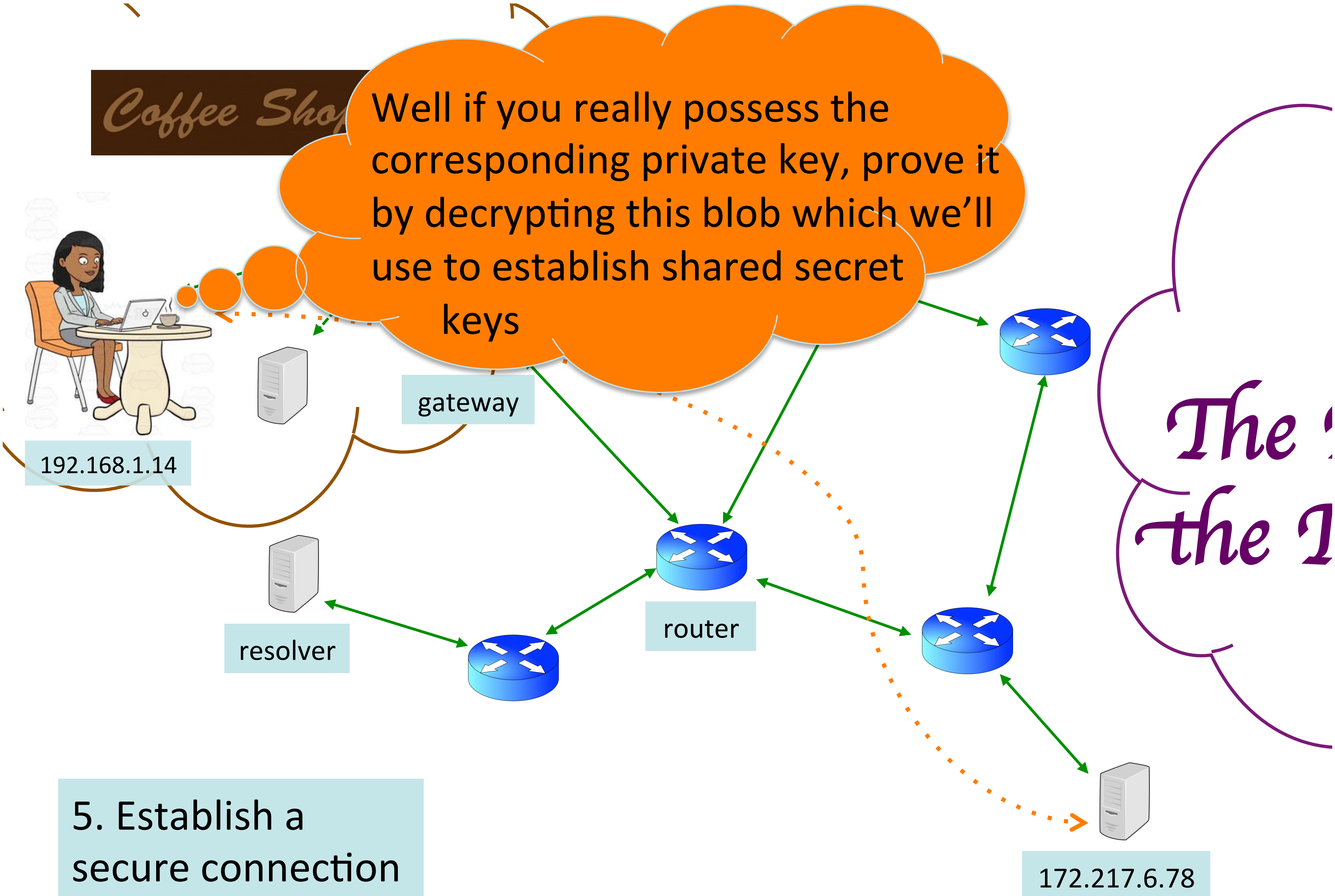

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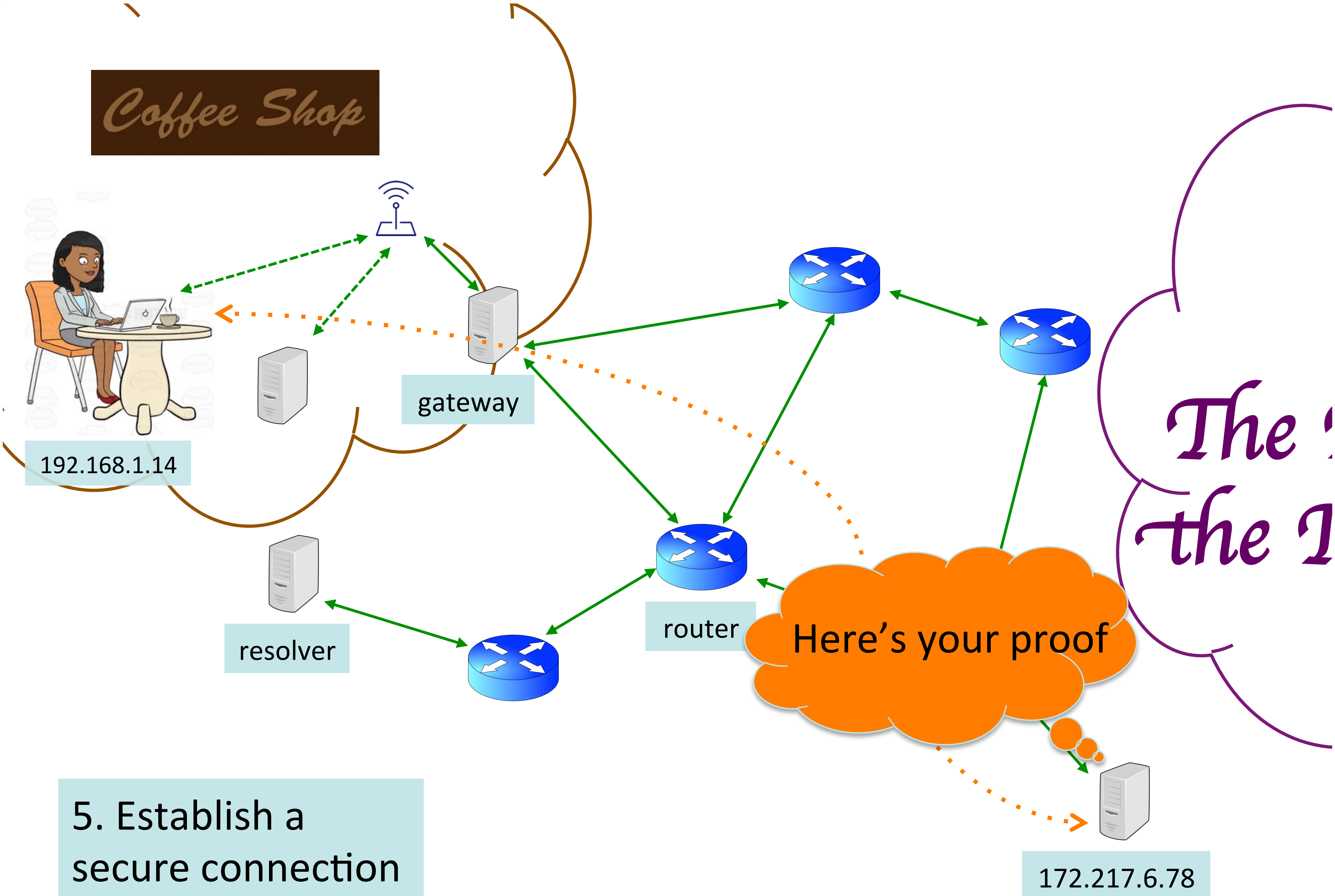

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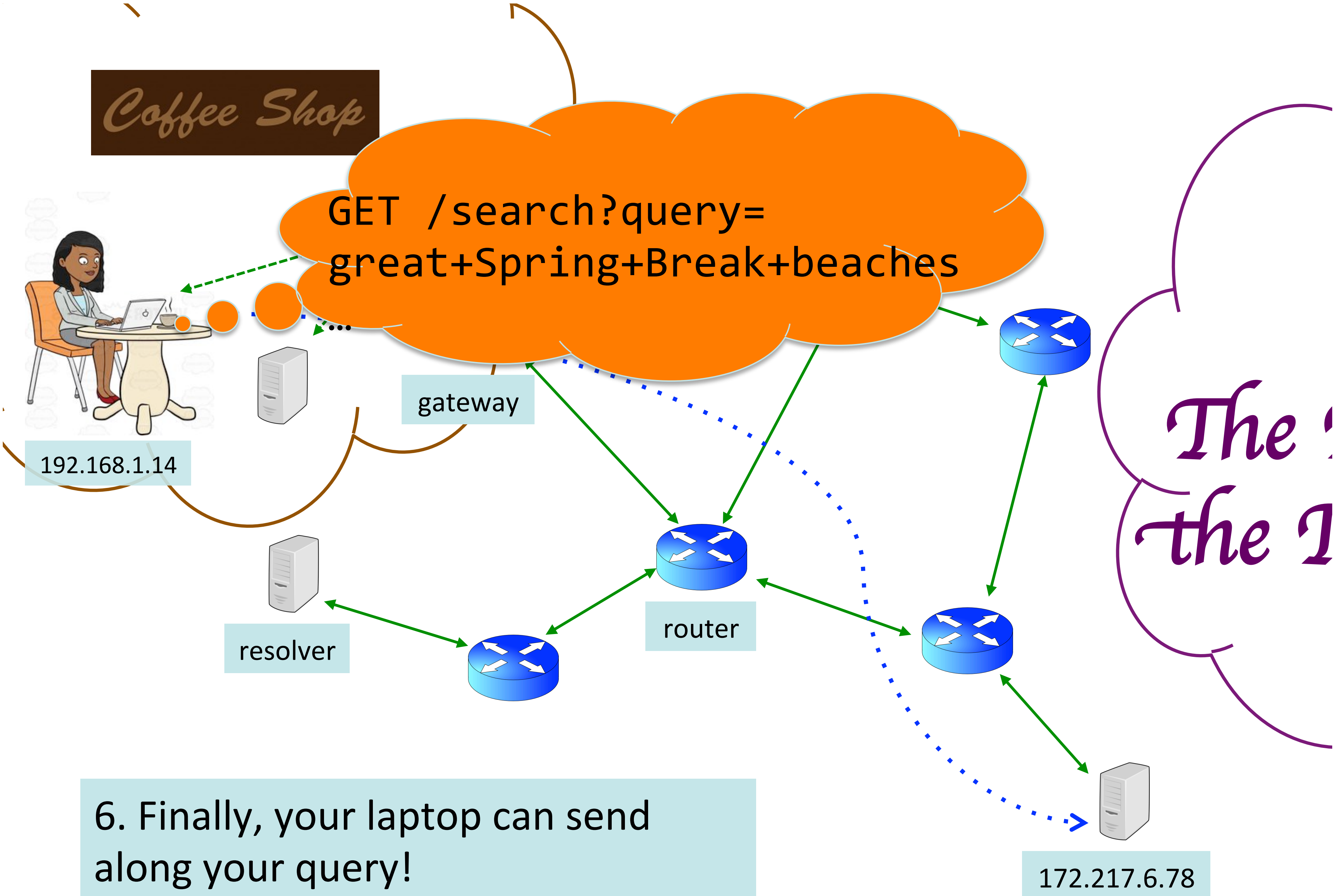


6. Finally, your laptop can send along your query!
(Using HTTP inside the *TLS channel*)

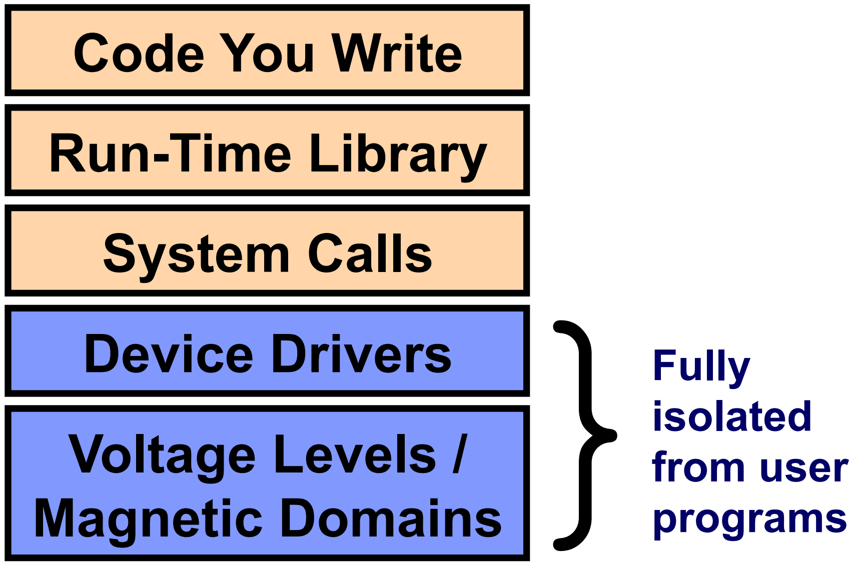
5 Minute Break

Questions Before We Proceed?

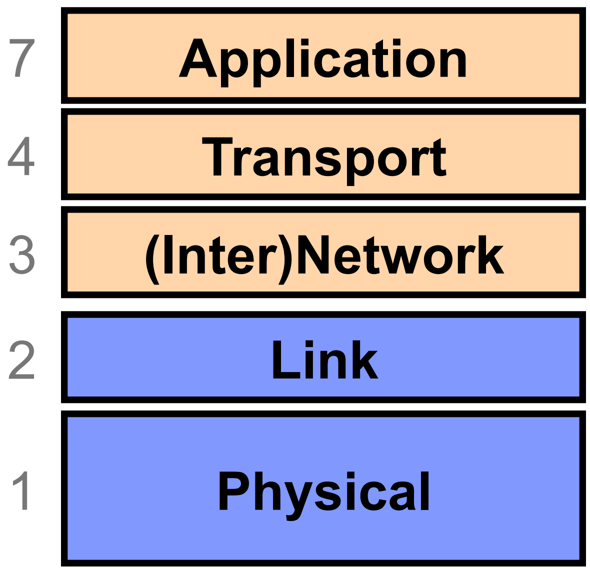
Internet Layering

Layering

- Internet design is strongly partitioned into layers
  - Each layer relies on services provided by next layer below …
  - … and provides services to layer above it
- Analogy:
  - Consider structure of an application you've written and the "services" each layer relies on / provides



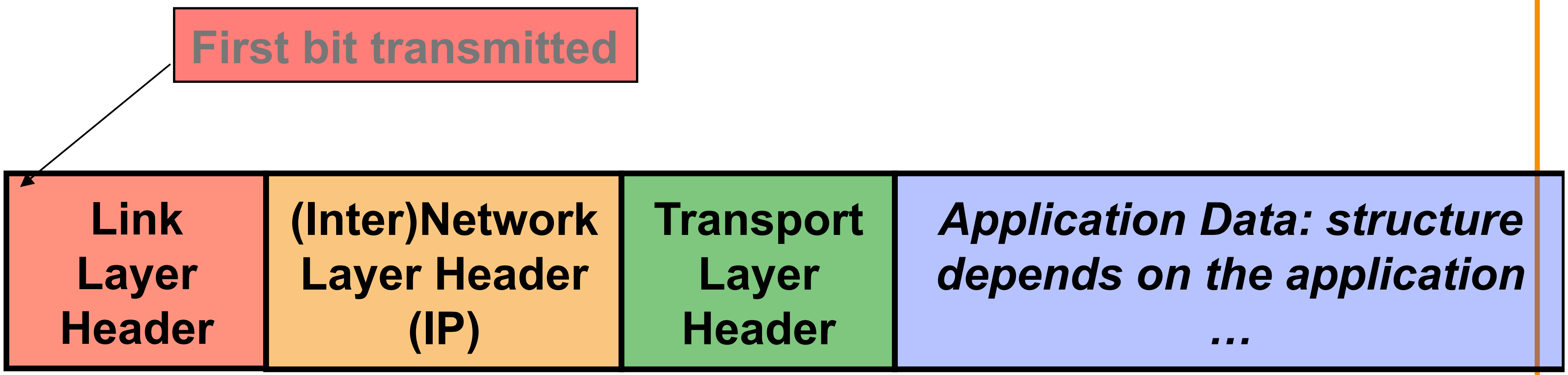
Internet Layering ("Protocol Stack")



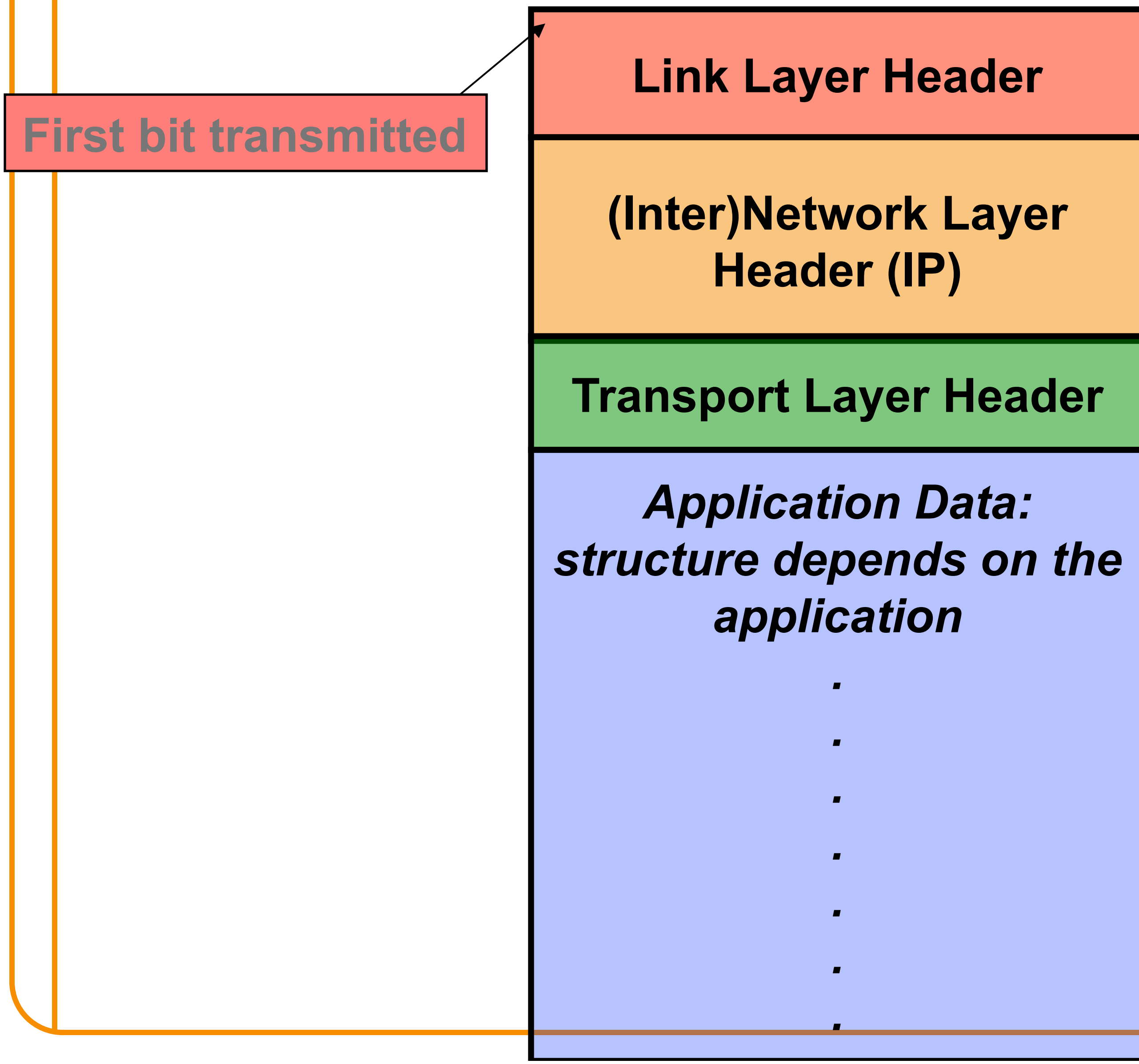
Note on a point of potential confusion: these diagrams are always drawn with lower layers **below** higher layers …

But diagrams showing the layouts of packets are often the *opposite*, with the lower layers at the **top** since their headers precede those for higher layers

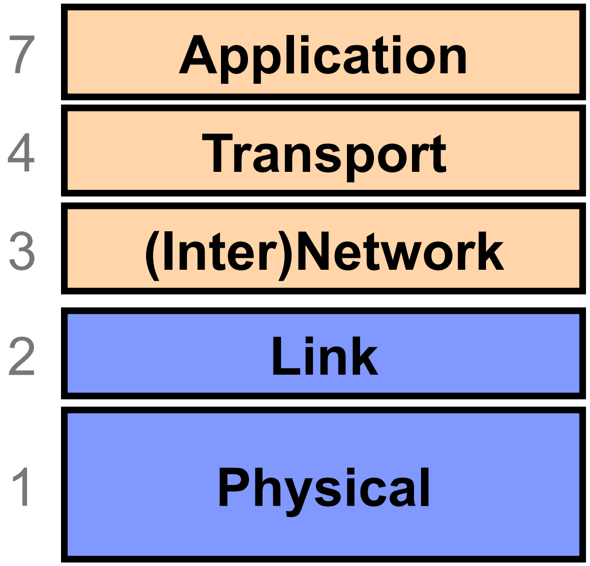
Horizontal View of a Single Packet



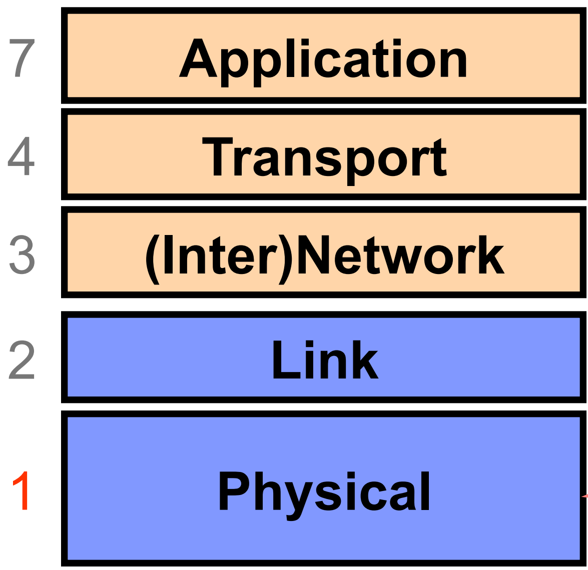
Vertical View of a Single Packet



Internet Layering ("Protocol Stack")



Layer 1: Physical Layer



Encoding bits to send them over a single **physical link**

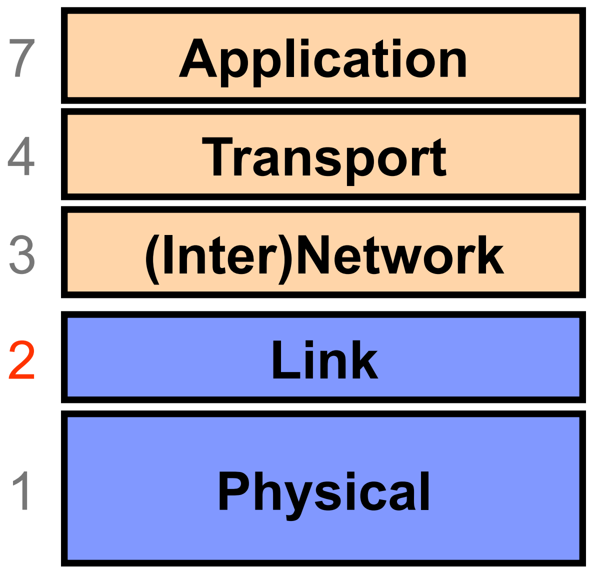
e.g. patterns of

voltage levels /

photon intensities /

RF modulation

Layer 2: Link Layer



Framing and transmission of a collection of bits into individual messages sent across a single "subnetwork" (one physical technology)

Might involve multiple *physical links* (e.g., modern Ethernet)

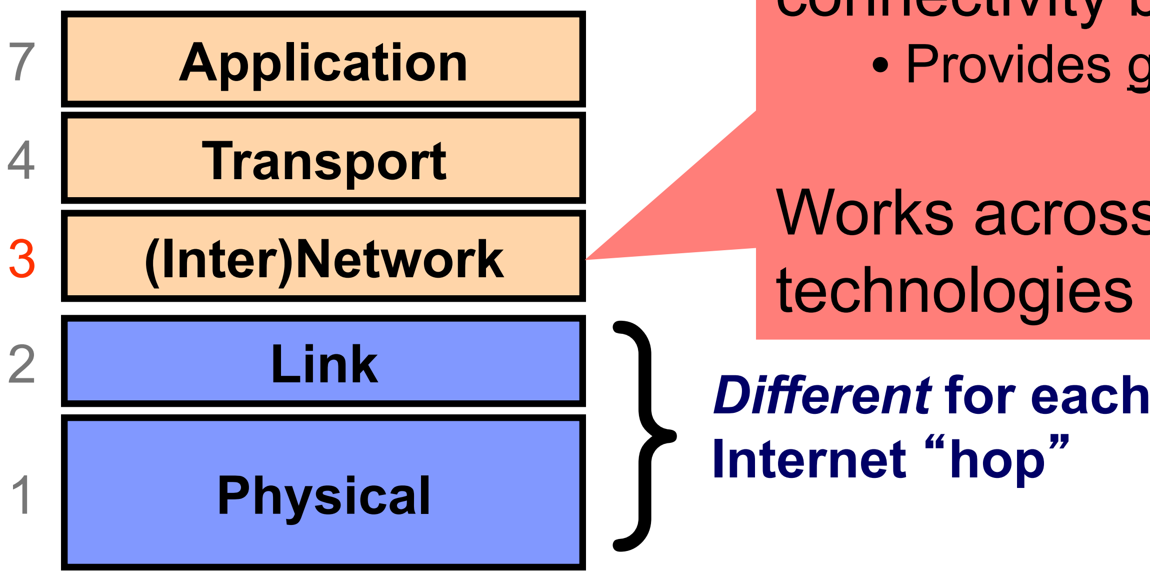
Often technology supports broadcast transmission (**every** "node" connected to subnet receives)

Layer 3: (Inter)Network Layer *(IP)*

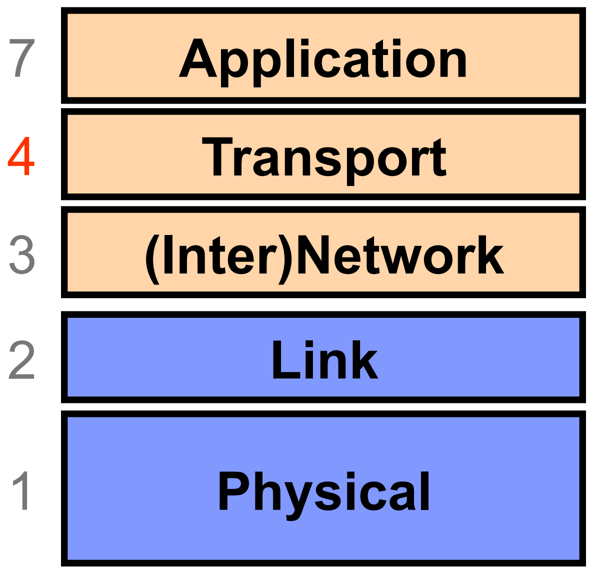
Bridges multiple "subnets" to provide *end-to-end* internet connectivity between nodes

- Provides global addressing

Works across different link technologies



Layer 4: Transport Layer

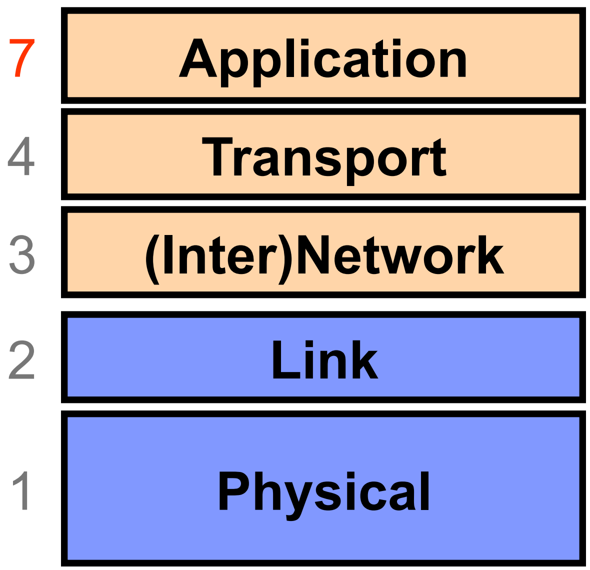


End-to-end communication between processes

Different services provided:
TCP = reliable *byte stream*
UDP = unreliable *datagrams*

(Datagram = single packet message)

Layer 7: Application Layer



Communication of whatever you wish

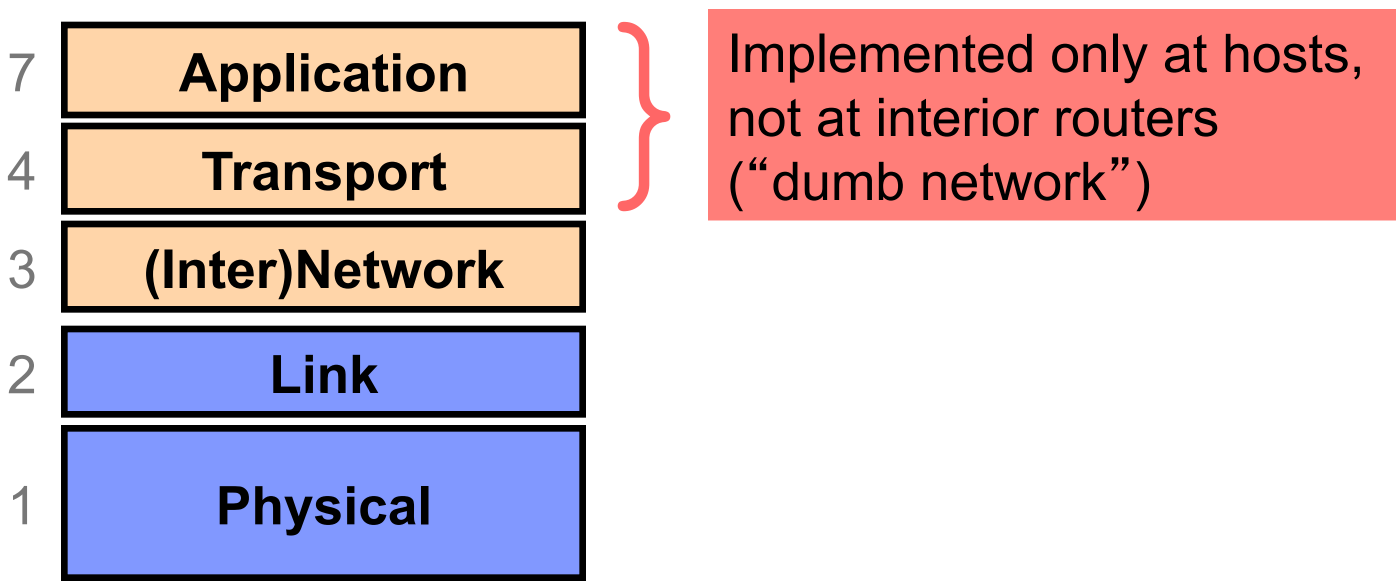
Can use whatever transport(s) is convenient

Freely structured

E.g.:

Skype, SMTP (email), HTTP (Web), Halo, BitTorrent

Internet Layering ("Protocol Stack")



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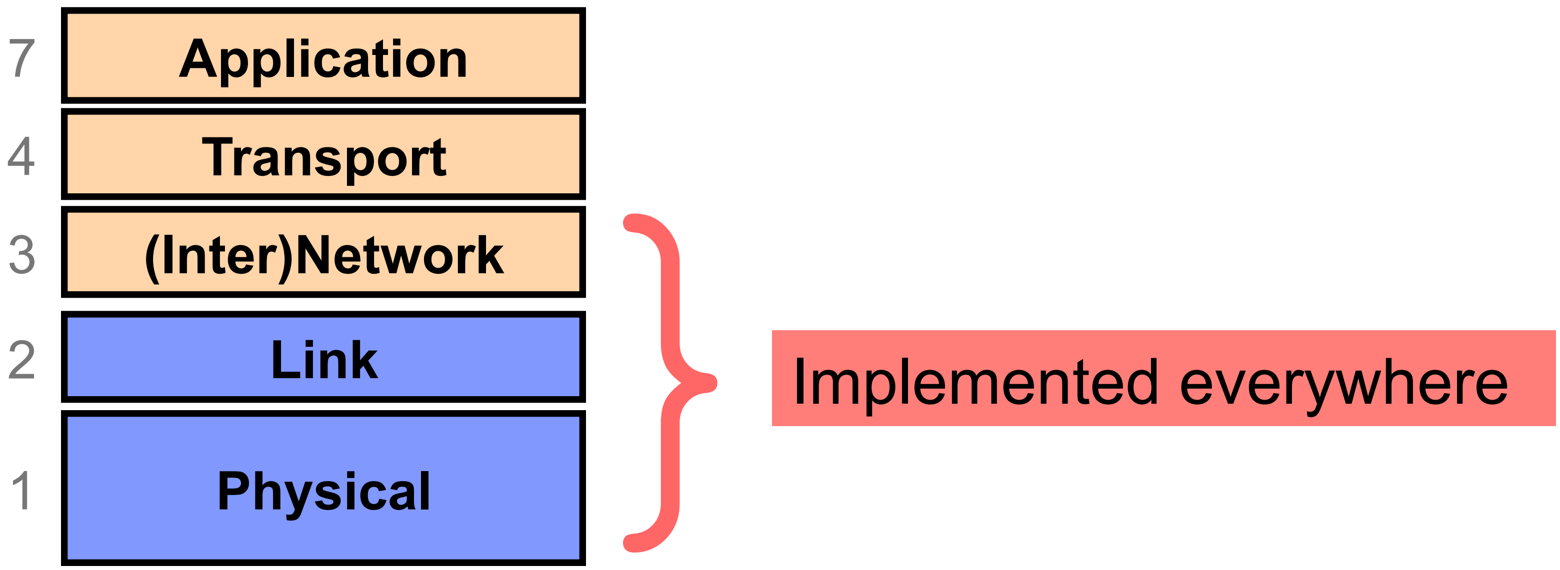

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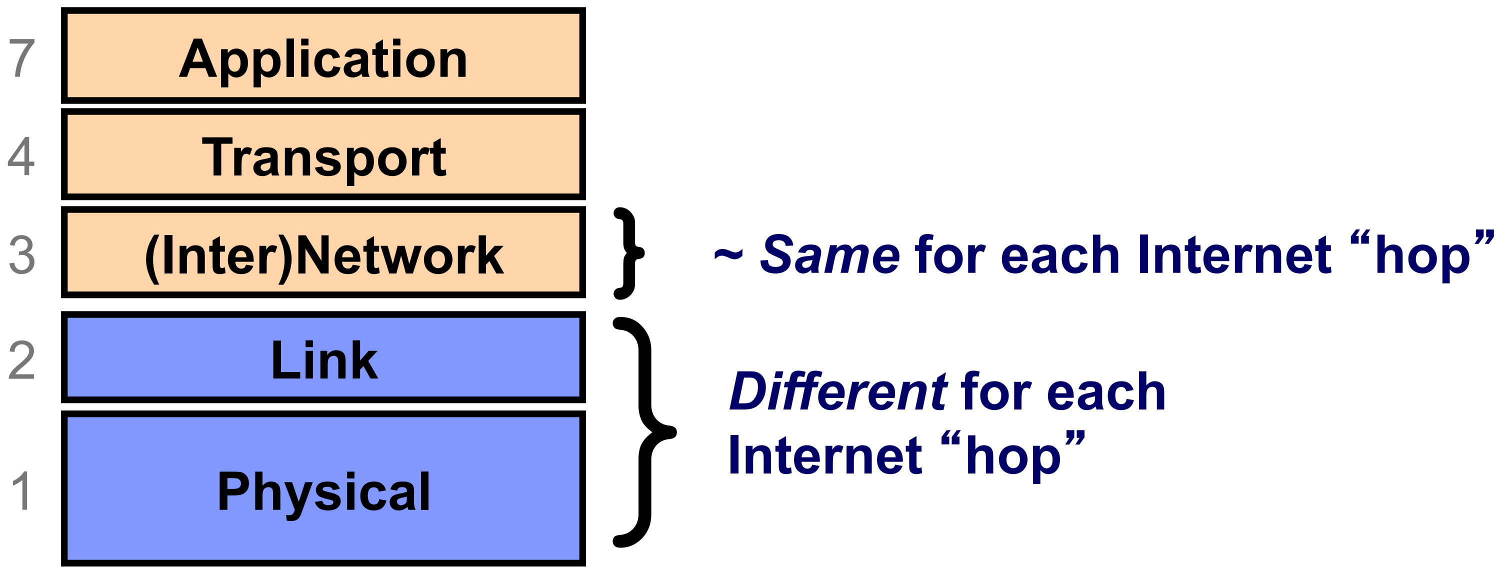
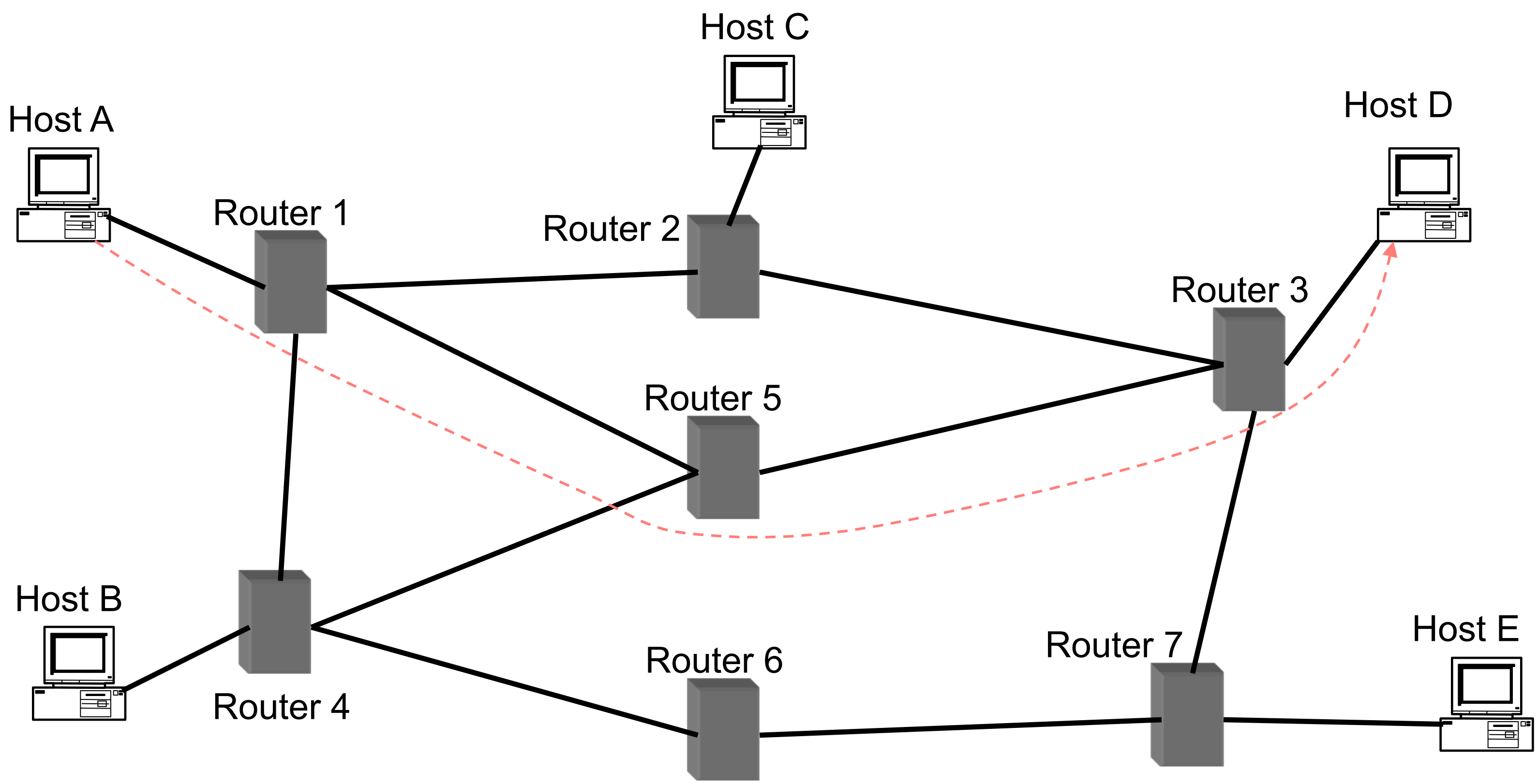


Hop-By-Hop vs. End-to-End Layers

Host A communicates with Host D



Hop-By-Hop vs. End-to-End Layers

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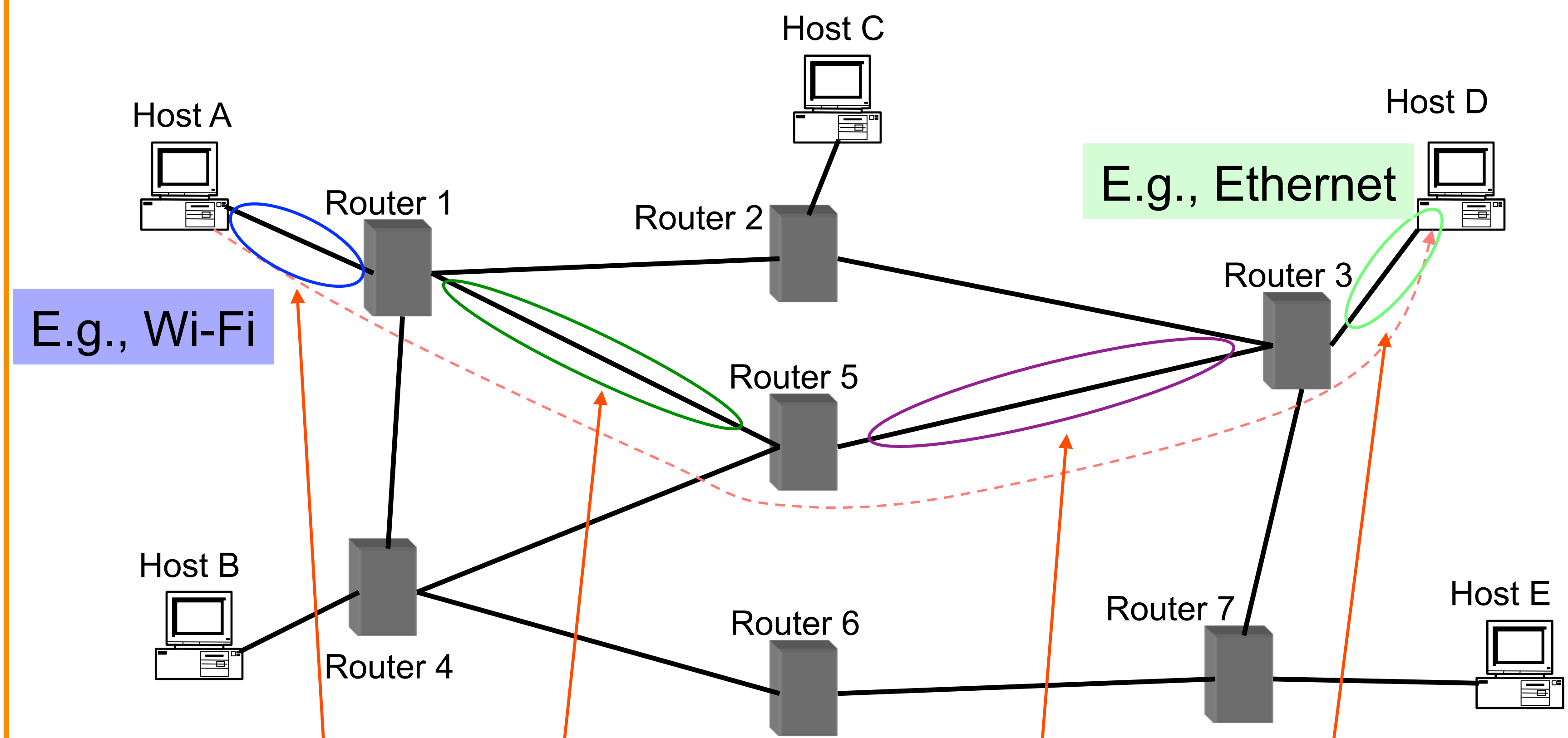
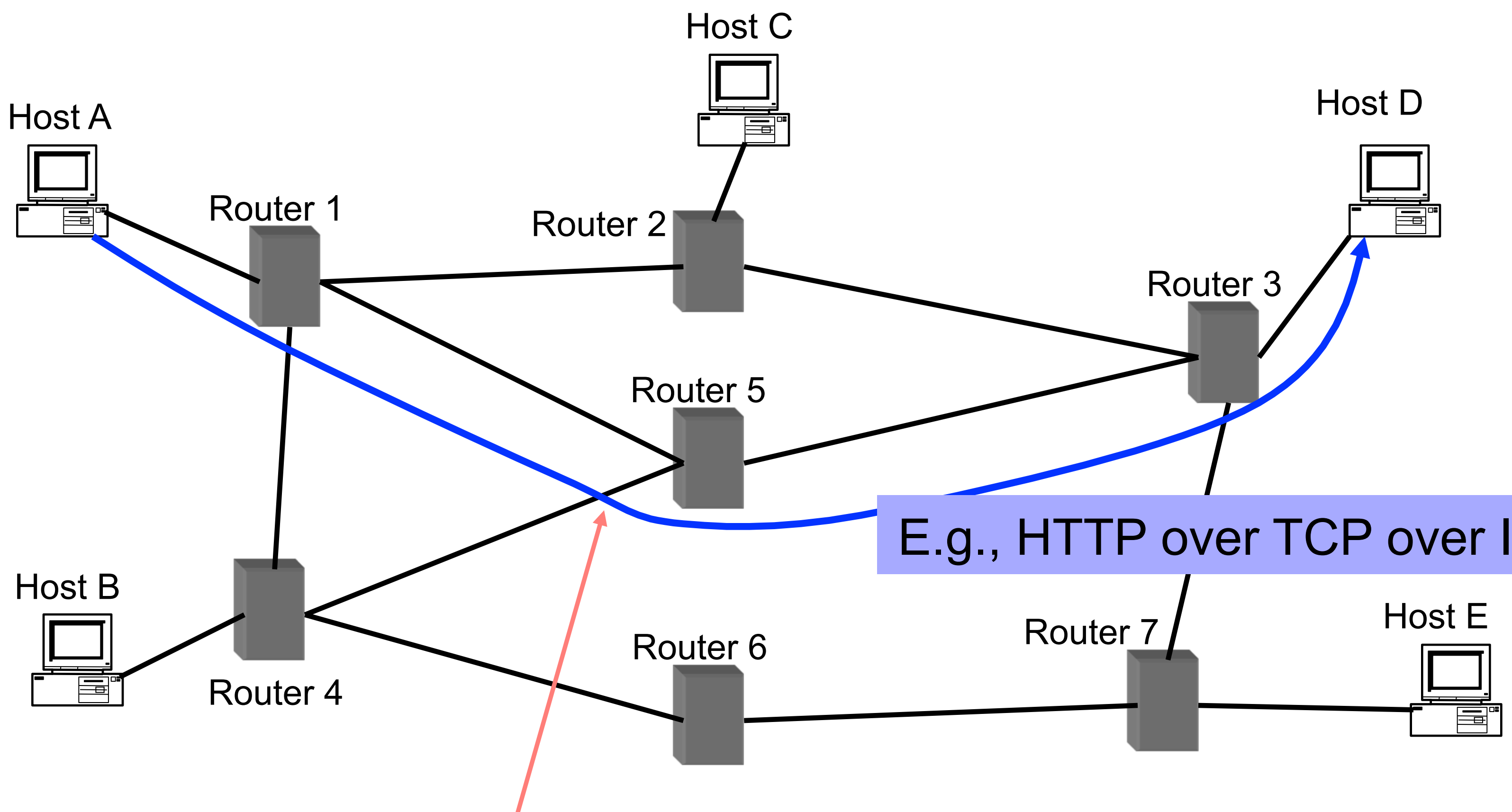


Different **Physical & Link Layers (Layers 1 & 2)**

Hop-By-Hop vs. End-to-End Layers

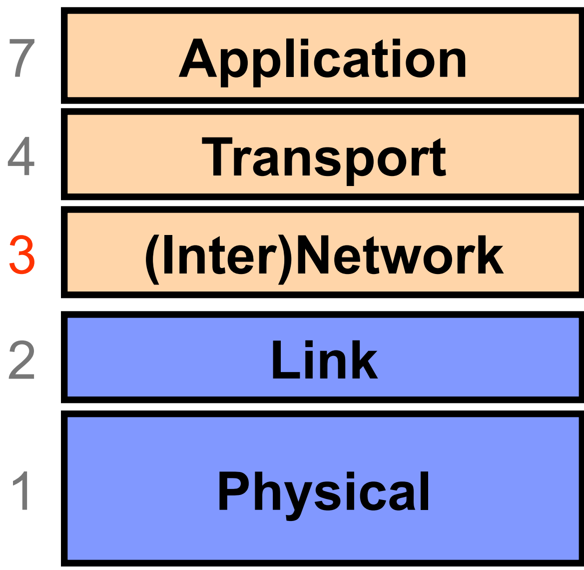
Host A communicates with Host D



E.g., HTTP over TCP over IP

Same Network / Transport / Application Layers (3/4/7)
(Routers **ignore** Transport & Application layers)

Layer 3: (Inter)Network Layer *(IP)*

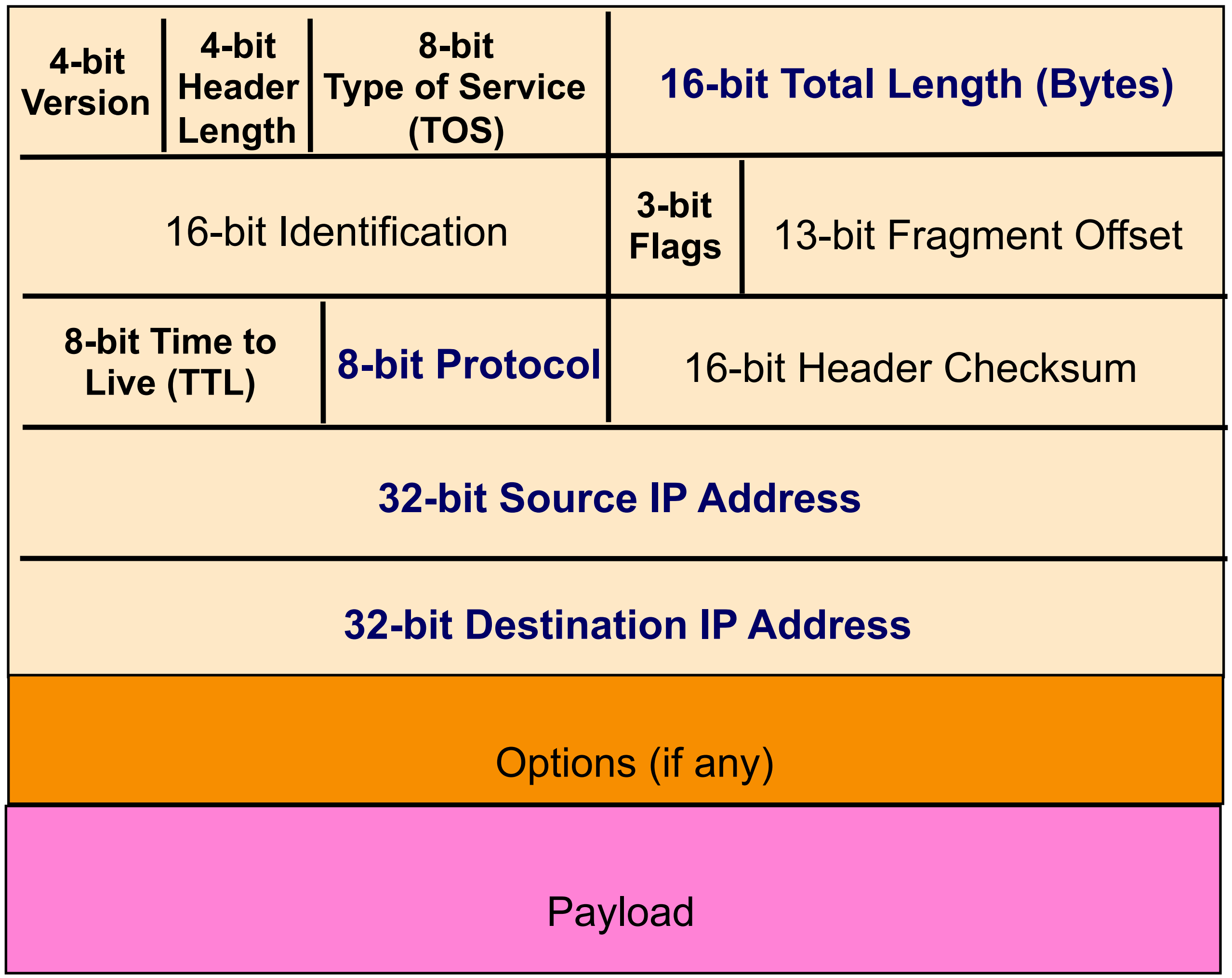


Bridges multiple “subnets” to provide *end-to-end* internet connectivity between nodes

- Provides global addressing

Works across different link technologies

IP Packet Structure



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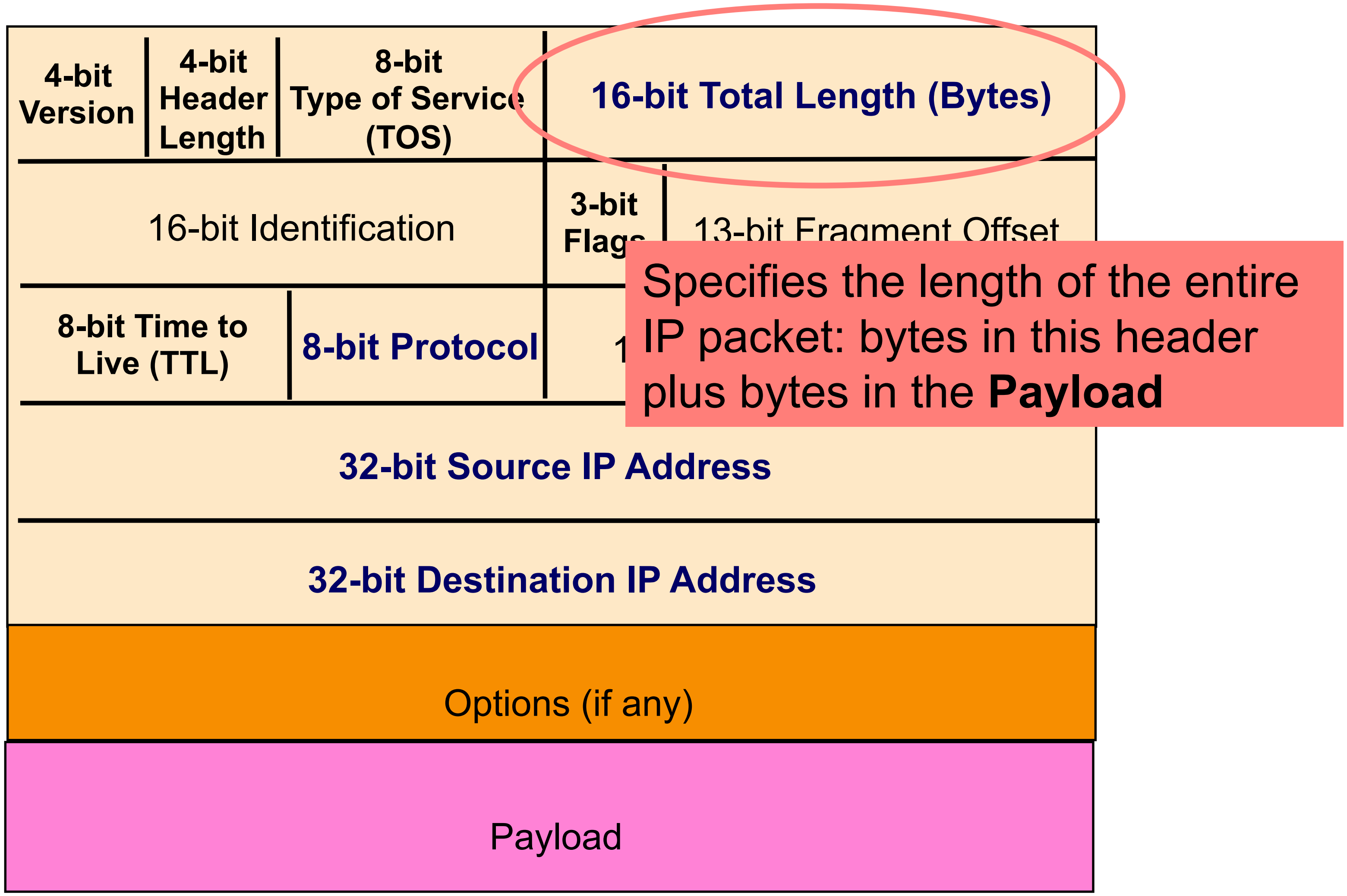

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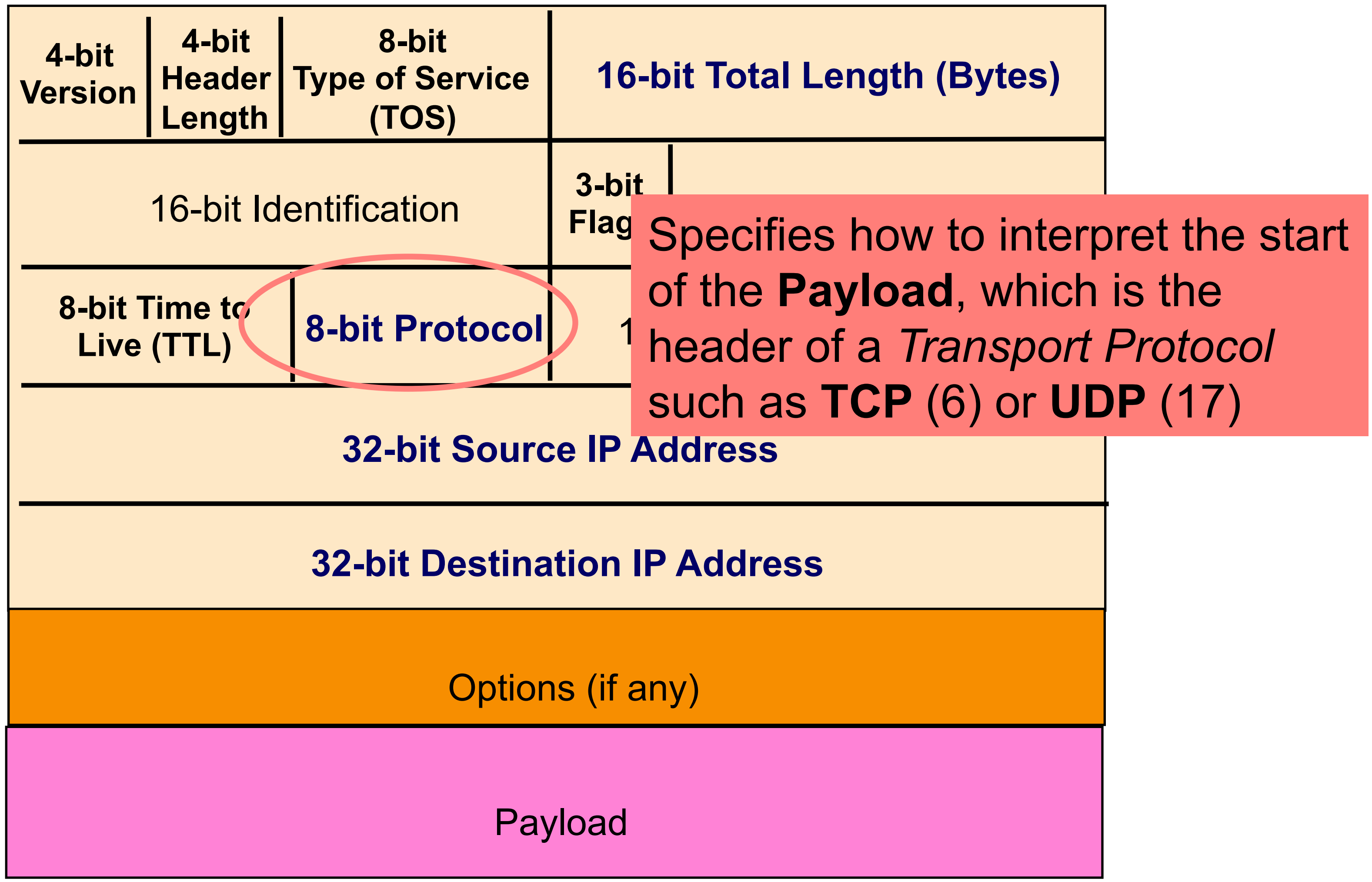

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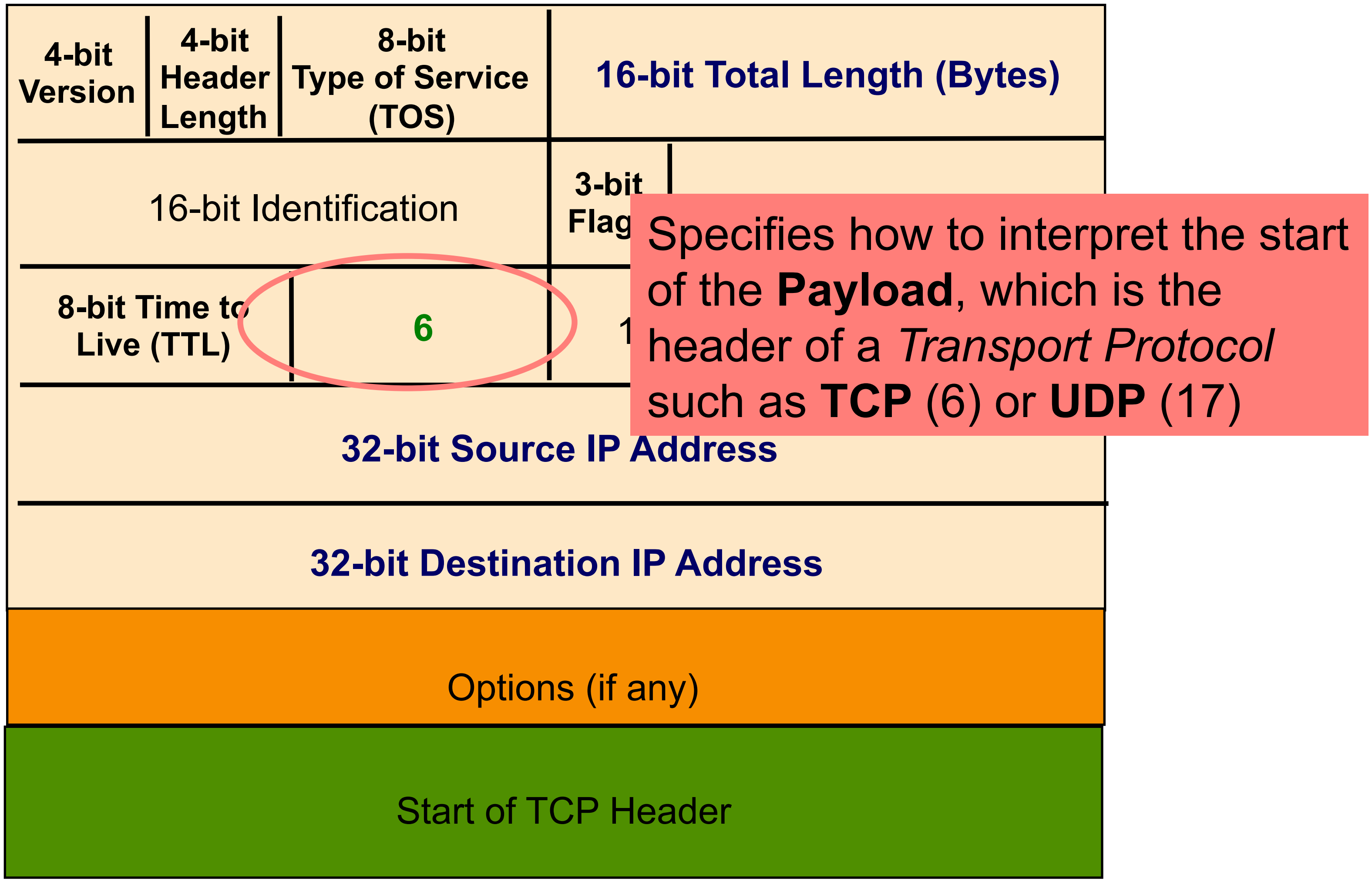
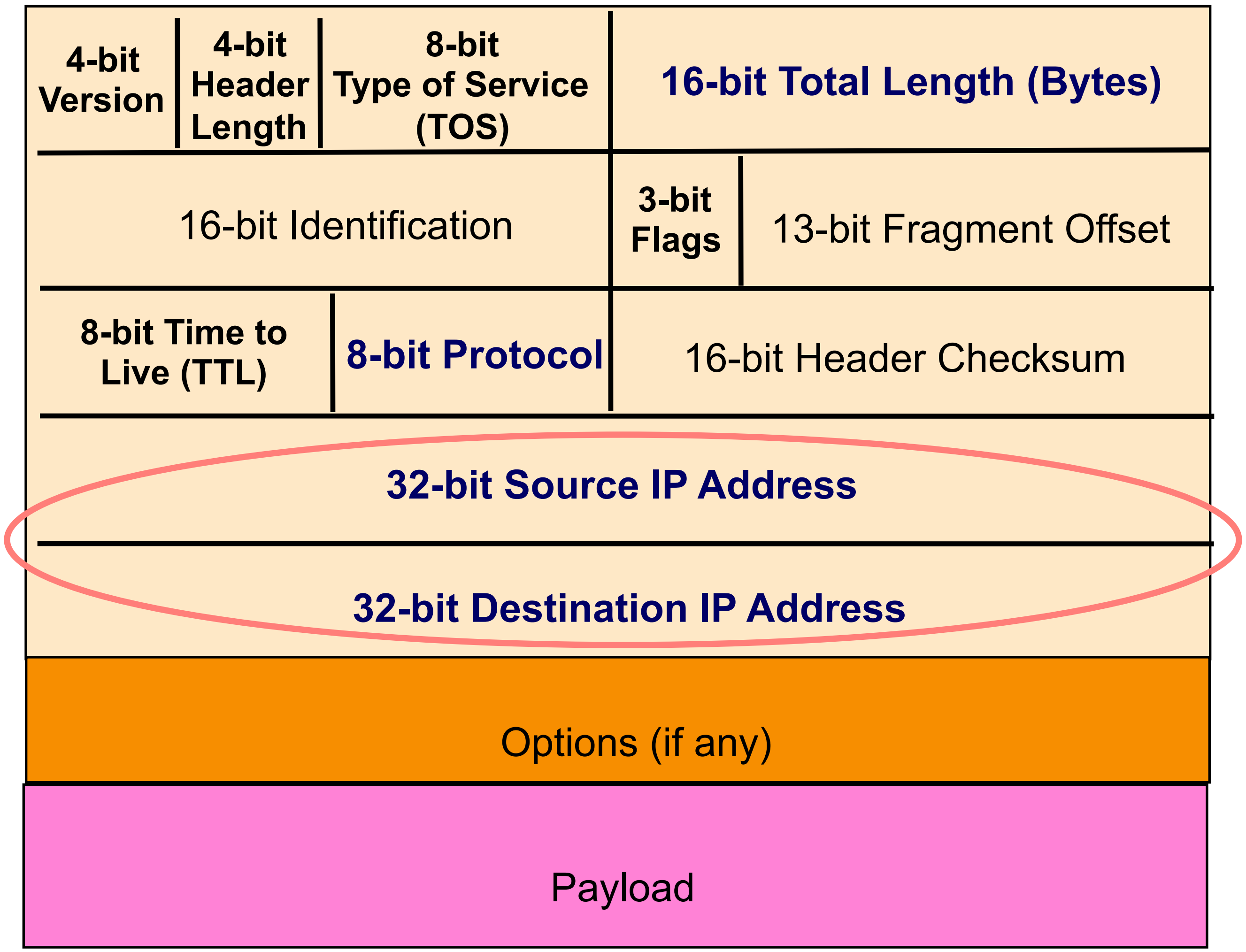


IP Packet Structure



IP Packet Header (Continued)

- Two IP addresses
  - Source IP address (32 bits in main IP version)
  - Destination IP address (32 bits, likewise)

- Destination address
  - Unique identifier/locator for the receiving host
  - Allows each node to make forwarding decisions

- Source address
  - Unique identifier/locator for the sending host
  - Recipient can decide whether to accept packet
  - Enables recipient to send reply back to source