# A Complete End-to-End View

DNS Server (9.9.9.9)

BERKELEY

AT&T

Wifi

Laptop

AP

DHCP Server/
Gateway Router

www.google.com
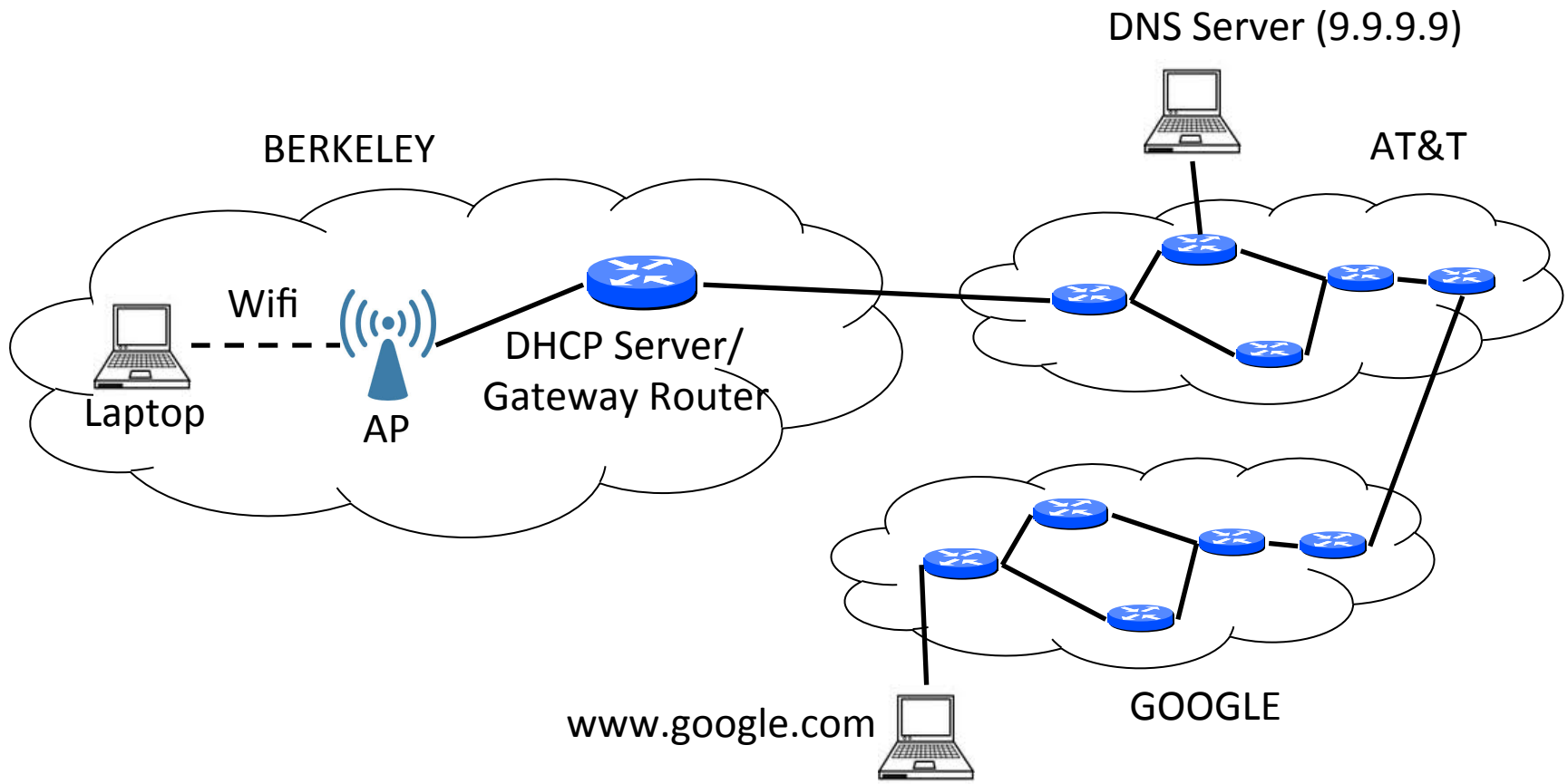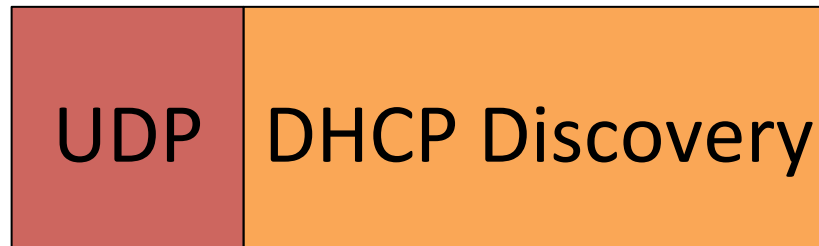
GOOGLE

# Step 1: Setting up the Network

To get an IP address, broadcast DHCP message that is picked by the DHCP server

DHCP Discovery

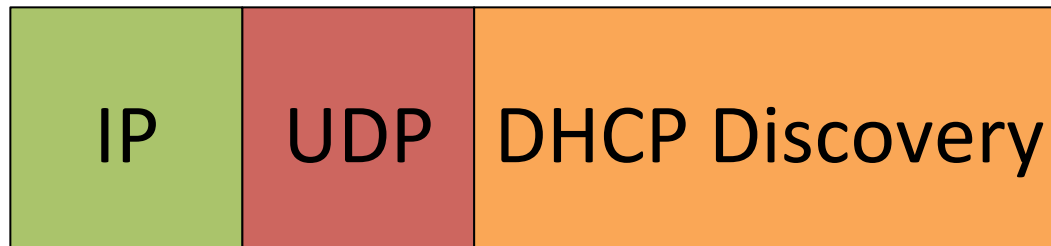# Step 1: Setting up the Network

It is a UDP packet sent on source port 68 and destination port 67

| UDP | DHCP Discovery |
|-----|----------------|

# Step 1: Setting up the Network

IP contains:
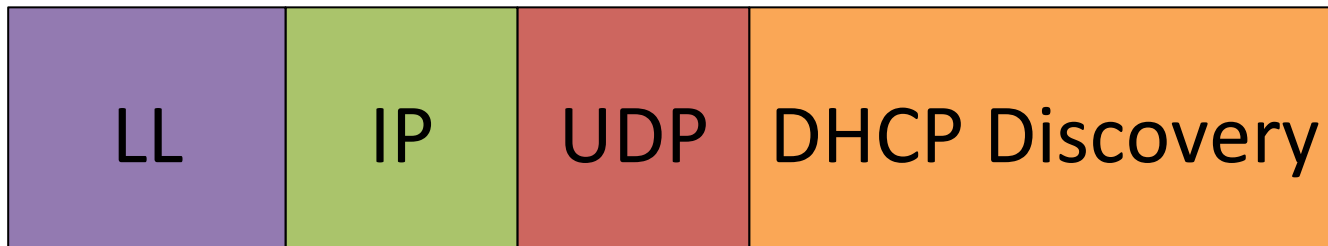
- Source Address: 0.0.0.0
  - We do not yet have an IP address
- Destination Address: 255.255.255.255
  - We broadcast the request

| IP | UDP | DHCP Discovery |
|---|---|---|

# Step 1: Setting up the Network

Add a Link Layer Frame (even Wifi has same format as Ethernet Frame)

- Destination MAC address is FF:FF:FF:FF:FF:FF
  - To broadcast

| LL | IP | UDP | DHCP Discovery |
|----|----|-----|----------------|

# Step 1: Setting up the Network

- Machine running DHCP server picks up the request
- Link Layer driver in the server shreds the LL header
- IP Layer of the kernel shreds the IP header
- UDP layer shreds the UDP header, after demultiplexing the packet to the server application running on port 67.
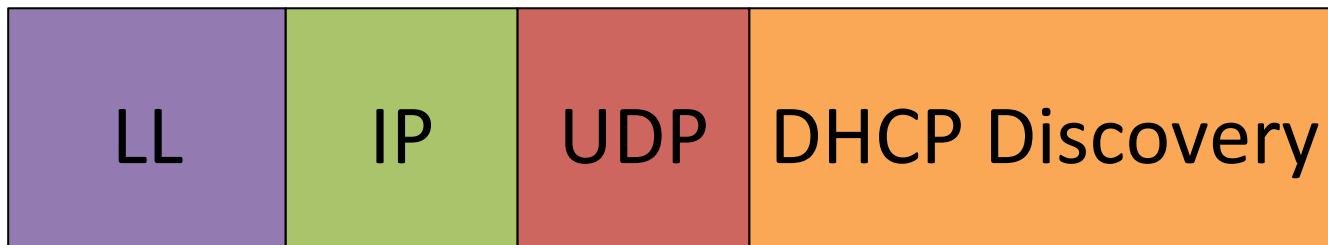
| LL | IP | UDP | DHCP Discovery |
|----|----|-----|----------------|

# Step 1: Setting up the Network

- Prepares an offer containing:
  - IP address of the requesting entity
  - DNS server's IP address
  - Default Gateway's IP address
  - Subnet Mask
- Encapsulated by UDP, IP and LL frames

| LL | IP | UDP | DHCP Offer |
|----|----|-----|------------|

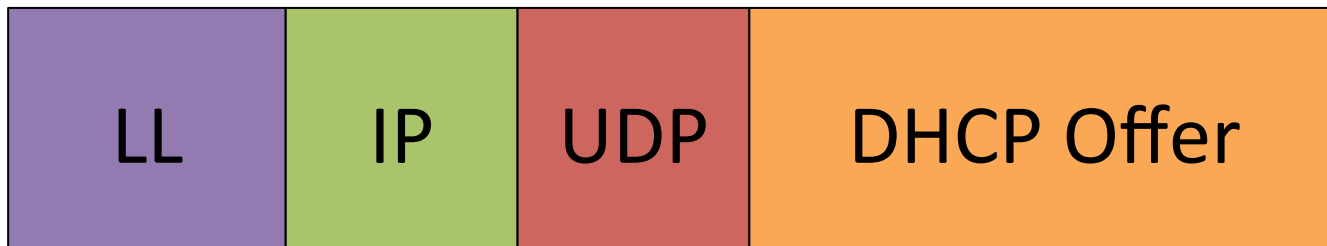# Step 1: Setting up the Network

- Prepares an offer containing:
  - IP address of the requesting entity
  - DNS server's IP address
  - Default Gateway's IP address
  - Subnet Mask
- Encapsulated by UDP, IP and LL frames

| LL | IP | UDP | DHCP Offer |
|----|----|-----|------------|
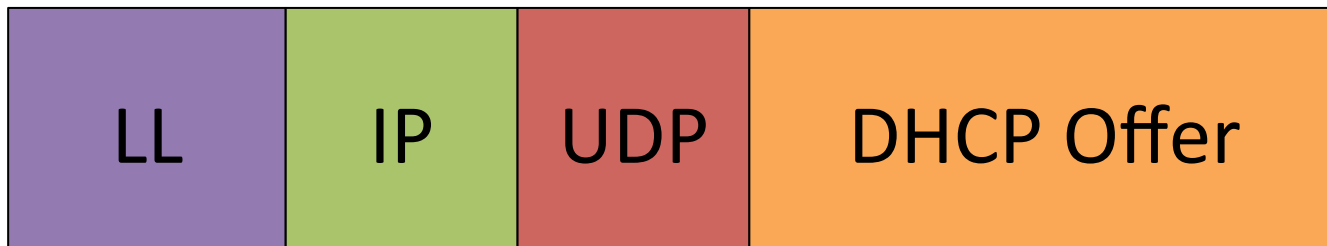
# Step 1: Setting up the Network

- Next Steps:
  - Client accepts an offer by broadcasting a "Request message
  - The server sends back an ACK

# If Ethernet Instead of Wifi?

| LL | IP | UDP | DHCP Discovery |
|----|----|-----|----------------|
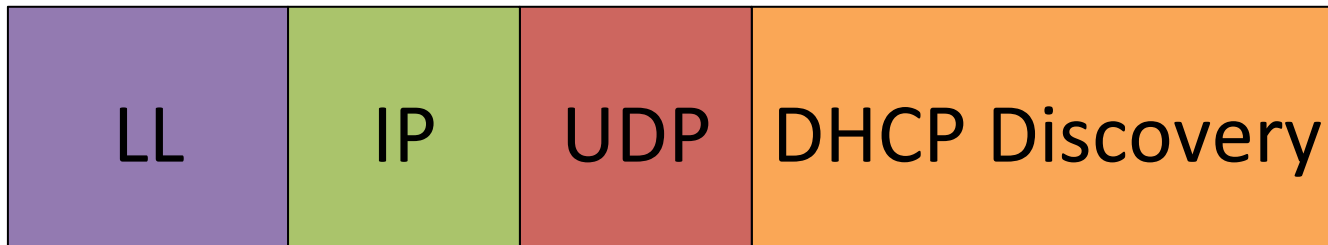
- The basic protocol remains same upto network
- Wifi and Ethernet use the same LL header
- Preamble and CRC added by Physical layer varies
- Technology used to transmit the packets varies
  - e.g. CSMA/CD for Ethernet CSMA/CA for Wifi, stronger reliability for Wifi etc

# Step 2: Getting Destination IP Address

Send a DNS request to the local DNS server to obtain IP address www.google.com
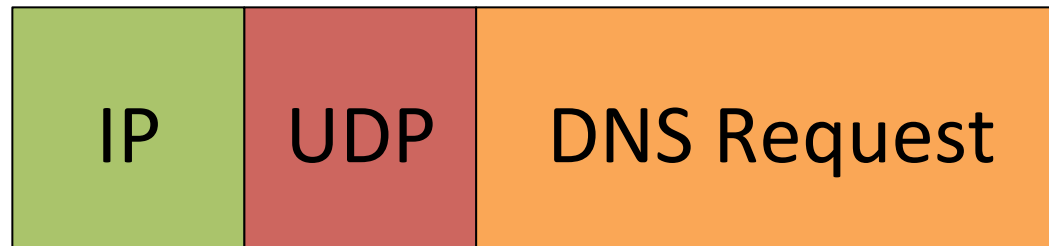
DNS Request

# Step 2:Getting Destination IP Address

It is a UDP packet sent on destination port 53

| UDP | DNS Request |
|-----|-------------|

# Step 2:Getting Destination IP Address

IP contains:

- Source Address: Obtained by DHCP

- Destination Address: Local DNS server's IP address (9.9.9.9), also contained DHCP response

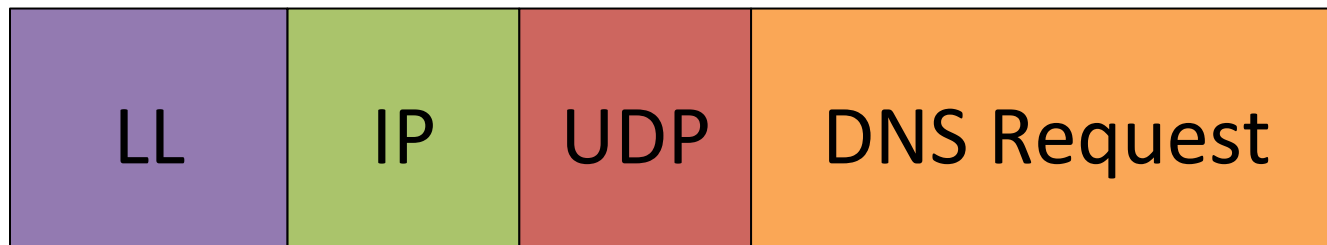| IP | UDP | DNS Request |
|----|-----|-------------|

# Step 2: Getting Destination IP Address

Add a LL frame

Destination MAC address??

- It knows that 9.9.9.9 is outside the subnet, since it knows the netmask from DHCP response

- Needs to route to the Default Gateway Router

- But its MAC address unknown

| LL | IP | UDP | DNS Request |

# ARP

- Broadcast an ARP request message
- ARP response from the Gateway Router contains the MAC address

| LL | ARP |

# Step 2: Getting Destination IP Address

- DNS request then processed by local server
  - Does the recursive querying to root, TLD and authoritative DNS server
- DNS response with [www.google.com](www.google.com)'s IP address

- Can save on complete iterative querying by local server if response if cached
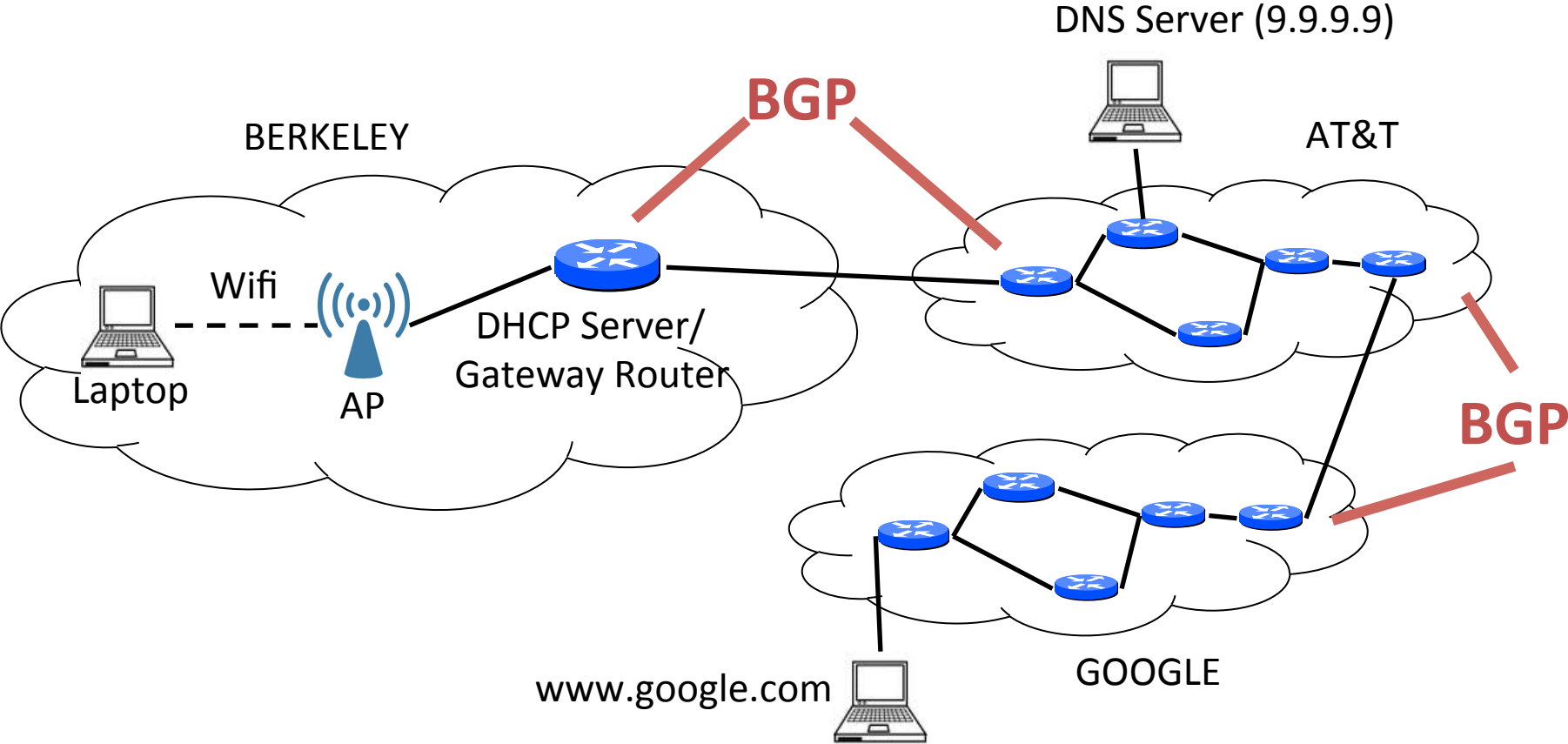
# Step 3: Requesting the Page

- Use HTTP to communicate with the destination's application
- TCP is the transport protocol used
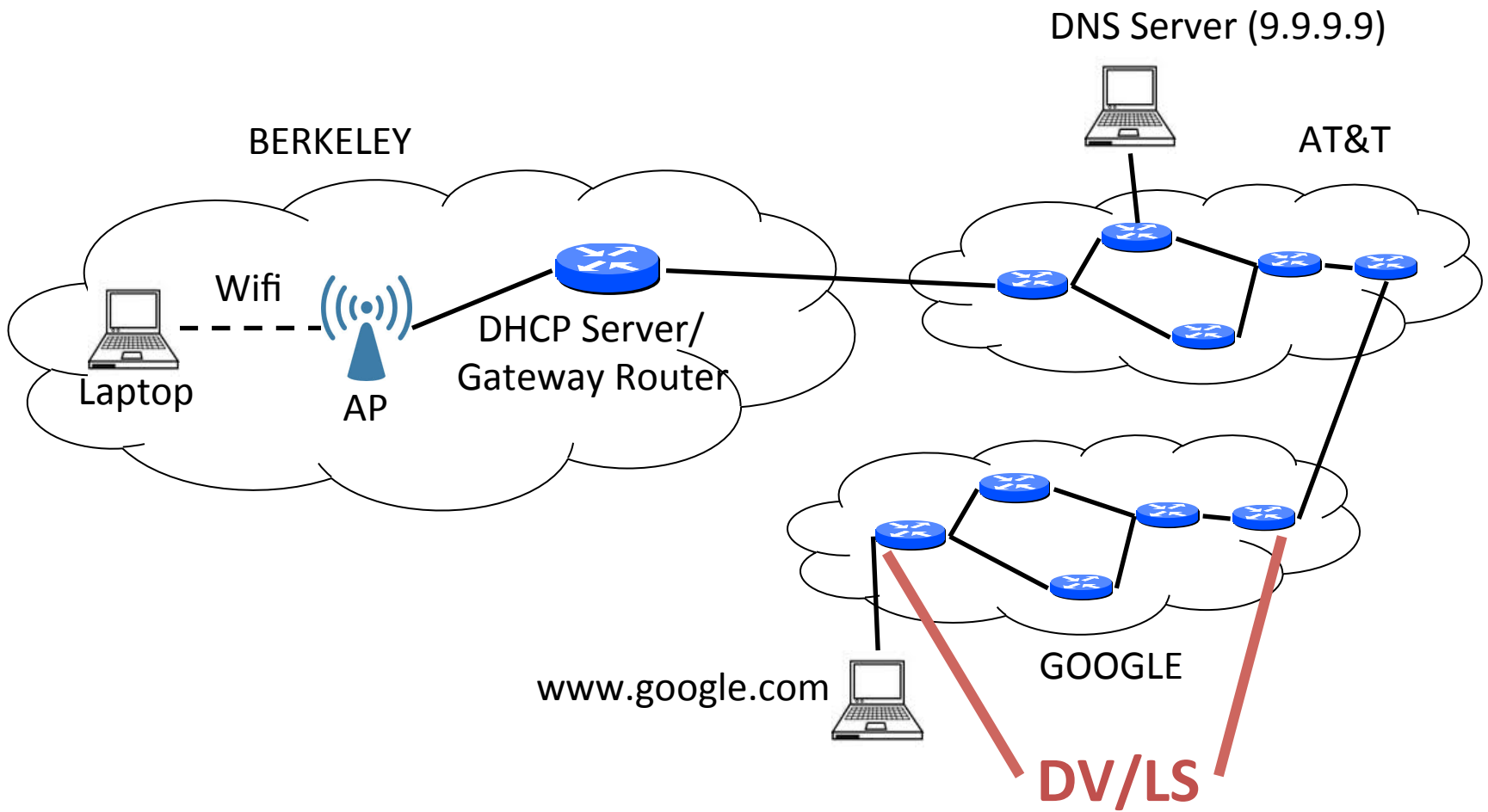- Encapsulated by IP and LL frames

| LL | IP | TCP | HTTP |
|----|----|-----|------|
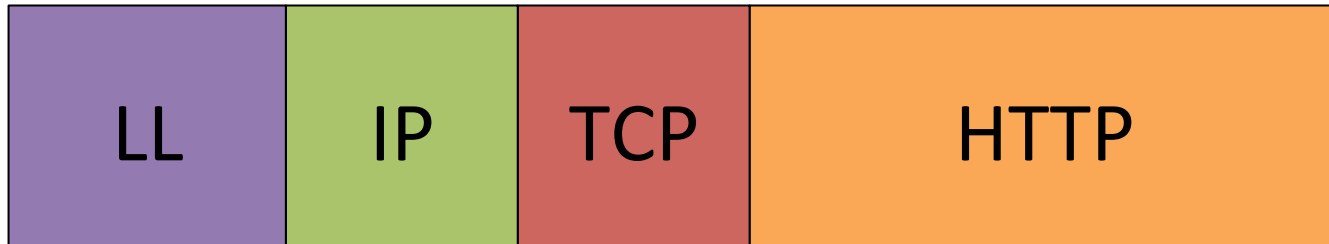
# How is a Packet Transmitted?

# Same network layer functionalities irrespective of transport or application layer protocols
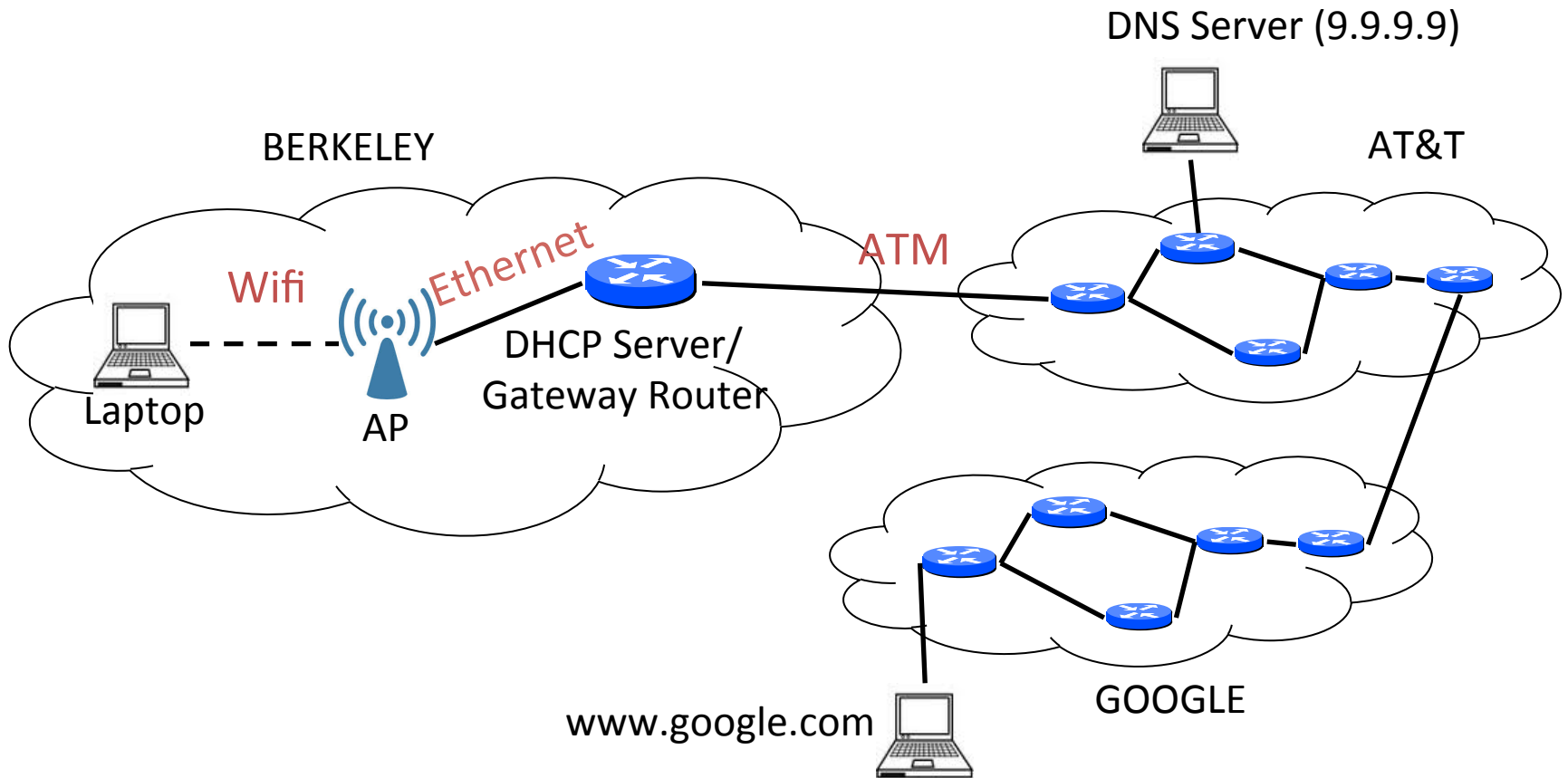
# Inter-Domain

# Intra-Domain

# Link Layer Technology Varies

# Transmitting Packet: All Layers View

**Source
A**

**Router
B**

**Router
C**

**Dest
D**

| Application | | | Application |
| a | | | a |

| Transport | | | Transport |
| a a | | | a a |

| Network | Network | Network | Network |
| a a a | a a a | a a a | a a a |

| Link Layer/Phy | Link Layer/Phy | Link Layer/Phy | Link Layer/Phy |
| a a a a | b a a a | c a a a | c a a a |