ICS 101 Fall 2013

Networking and the Internet

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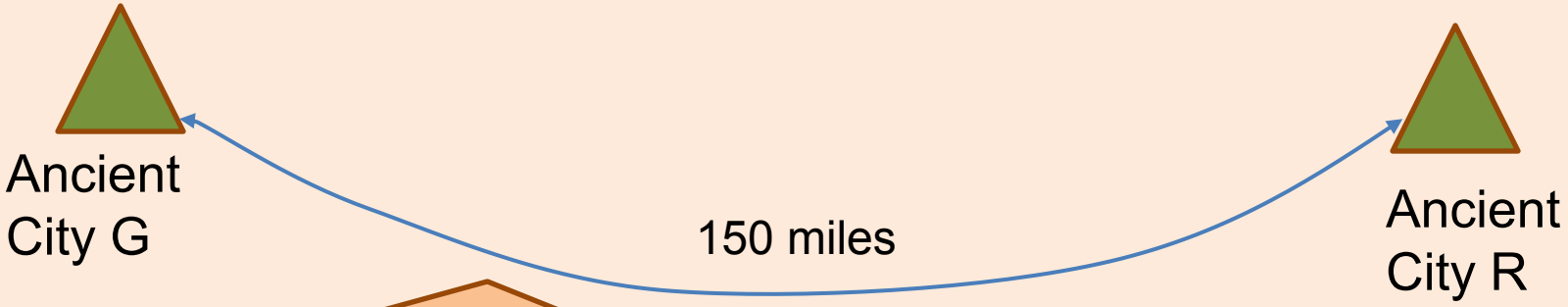
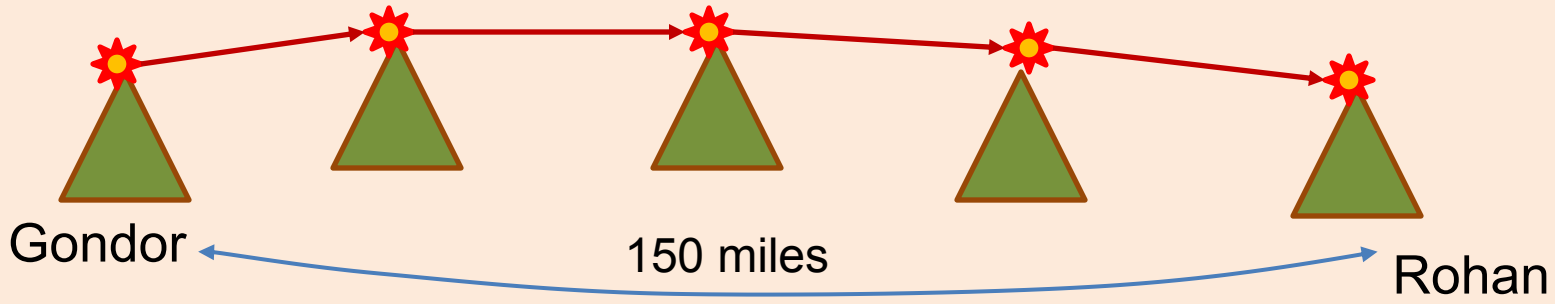
Problem

- Ancient cities G and R have a made a pact that each will come to the (military) aid of the other if one is in trouble.



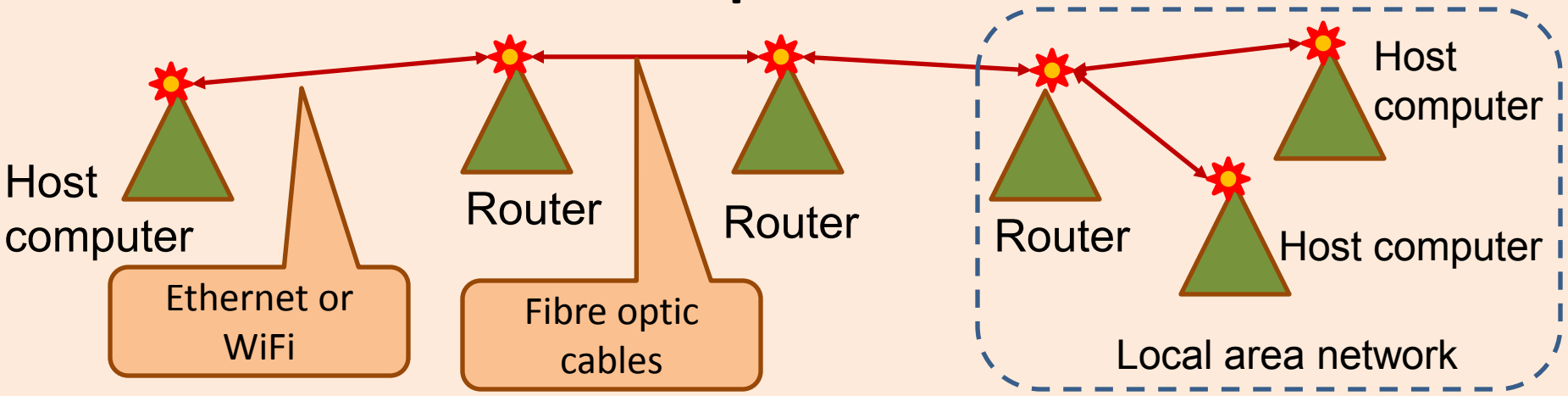
G & R are 150 miles apart.
How can they send a message for help quickly ?

LOTR: Beacon of Gondor



- Video: http://www.youtube.com/watch?v=i6LGJ7evrAg
- Transmission medium: air- line of sight
- Data encoding: 1 bit – fire or no fire
- All receivers have to be listening
- Agreed upon interpretation of the signal at the endpoints
- Intermediate beacon wardens are always looking for a signal and relaying the signal
- One way communication

Modern Computer Networks



- Signaling technology can transmit complex sequences of bits - packets
- Each host or router obeys a set of rules for how to handle incoming/outgoing messages – communication protocols
- Communications can be multi-way
- Bandwidth: the number of bits that can be transferred per second (bps)
- Latency: the time it takes for a message to reach the destination after leaving the source

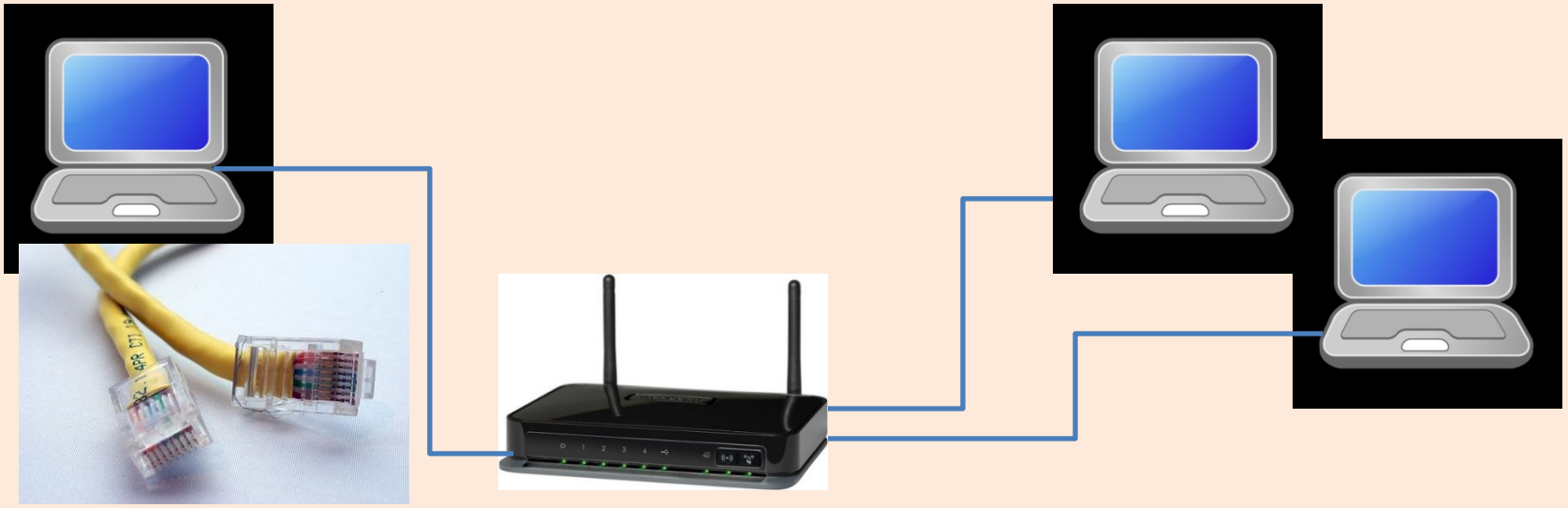
Quiz 1

- **What is the *bandwidth* between two communicating nodes A & B?**
  a) How long it takes for 1 bit to travel from A to B
  b) How much data can travel from A to B in one unit time
  c) How far apart A and B are
  d) How long it takes a beam of light to travel from A to B

Quiz 2

- **What is the *latency* between two communicating nodes A & B ?**
  a) How long it takes for 1 bit to travel from A to B
  b) How much data can travel from A to B in one unit time
  c) How far apart A and B are
  d) How long it takes a beam of light to travel from A to B

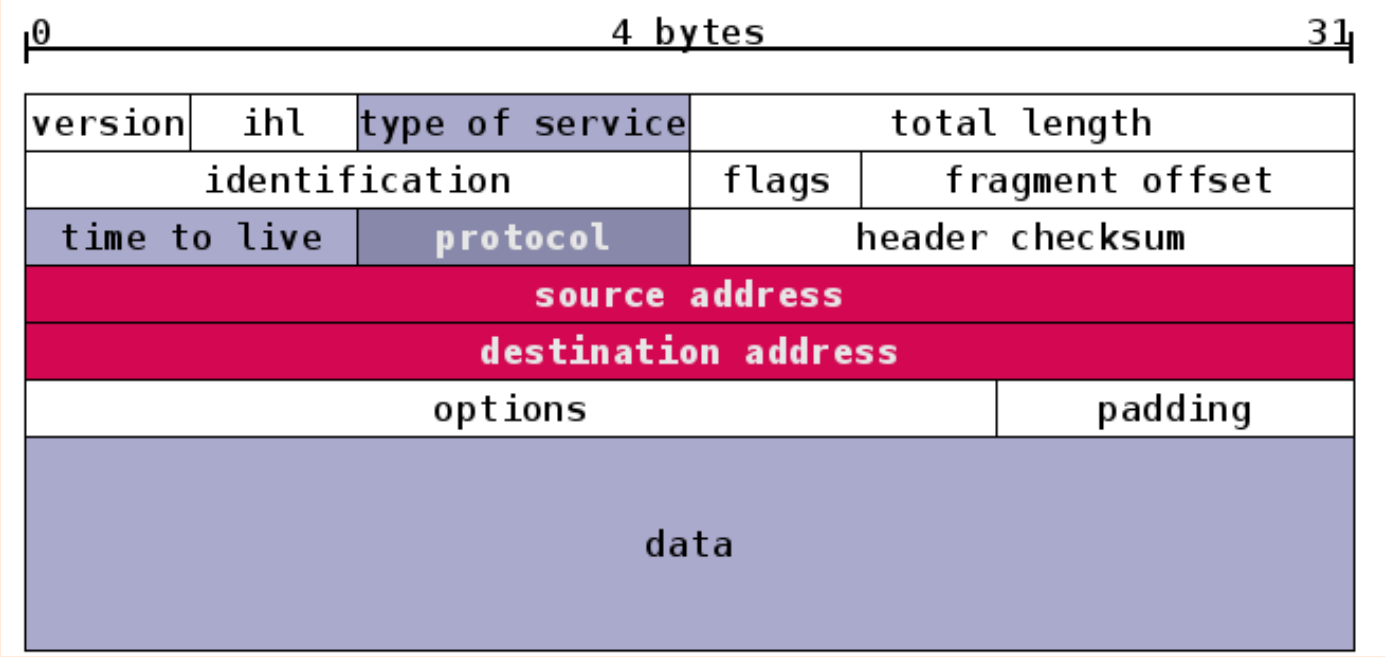
Local Area Networks



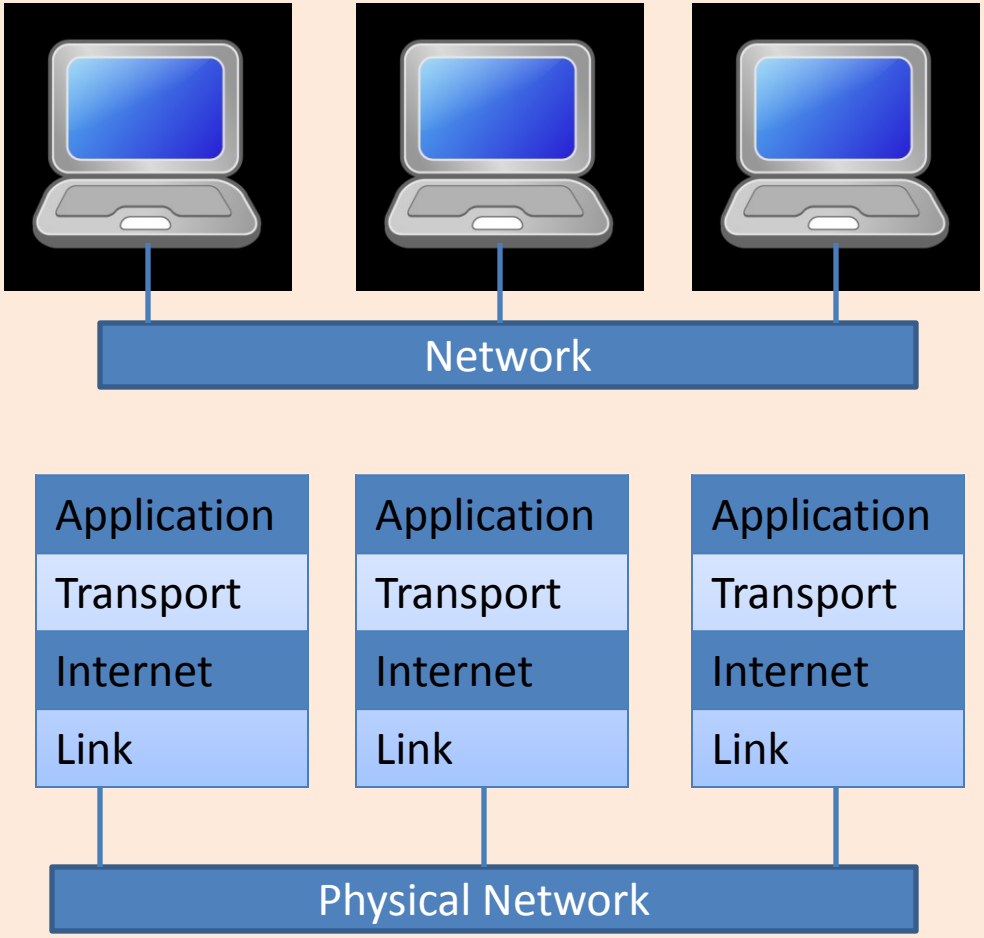
- Wired (UTP Cat5) or Wireless 802.11
- Connects hosts within a limited spatial region together to form a network
- All hosts within the network can “talk” to each other
- The network is often a shared medium: only one host can talk at one time and the rest listens.

Data Packet

- How messages are packaged for delivery on the network – like postal mail.
- Source and destination addresses

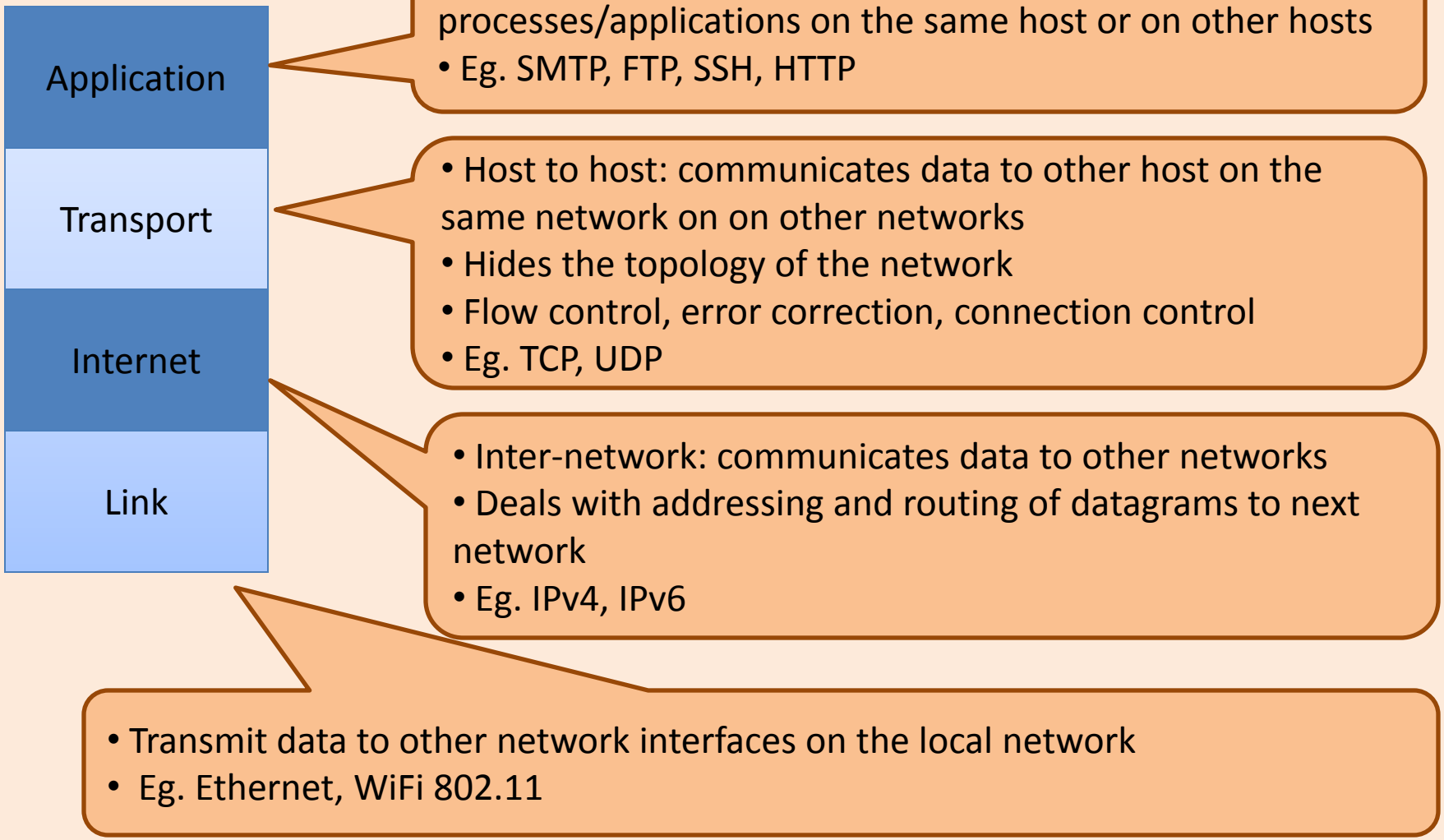


Network Abstractions

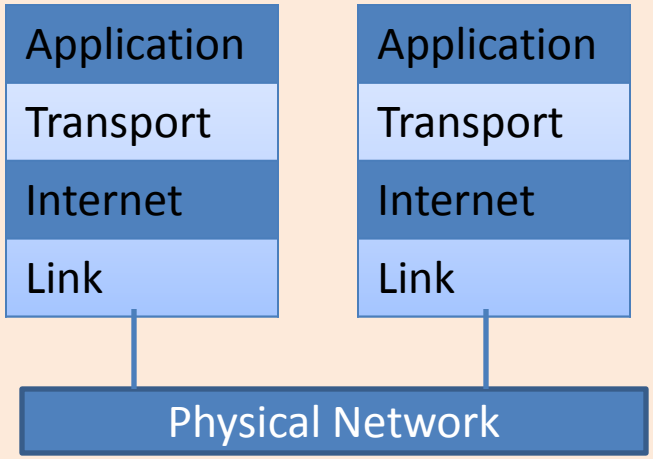


- Network communications are conceived as layers of abstractions.
- Each layer plays a specific role and is relatively independent of other layers
- Each layer has its own packet format
- Packets from higher layers are embedded in packets of lower layers – "encapsulation"

TCP/IP Four Layer Model



Link Layer



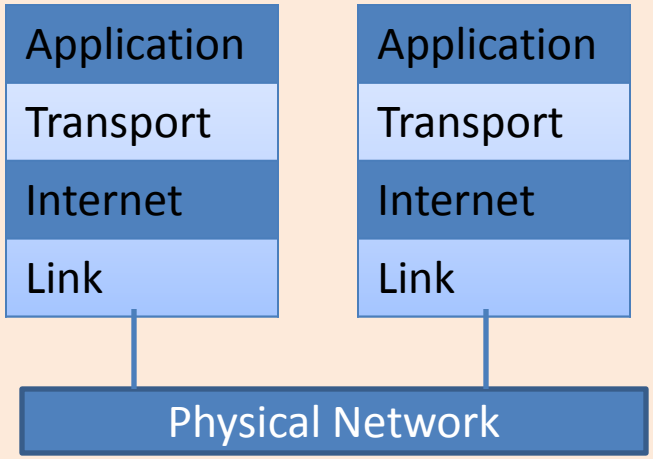
- Eg. Ethernet, WiFi 802.11
- A host can have multiple network interface cards (eg. Laptops typically have an ethernet interface and a WiFi interface)
- Each interface has a 48-bit physical address that is hardwired to the hardware

Data packet arrives from upper layer (Internet layer)

- If packet is too big, break packet into smaller fragments (`frames')
- Embed data packet in a link layer packet with link layer header, sequence number, error correction code etc.
- Link layer packets gets transmitted on physical link
- Link layer protocol governs how transmission over physical link is done. Eg. Carrier sense multiple access

Bottom-up process is similar on the receiving host

Internet Layer



- Eg. IPv4
- Connects multiple networks together.
- Each network interface of a host is associated with an 32-bit IPv4 address
- IP address is not hardwired, but assigned in the software

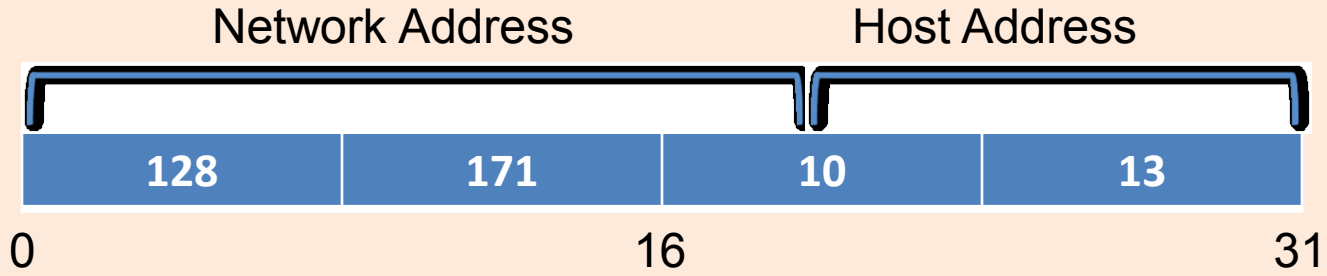
Data packet arrives from Transport layer

- Embed data packet in an IPv4 packet with IP header etc.
- Pass packet to Link layer

Data packet arrives from Link layer

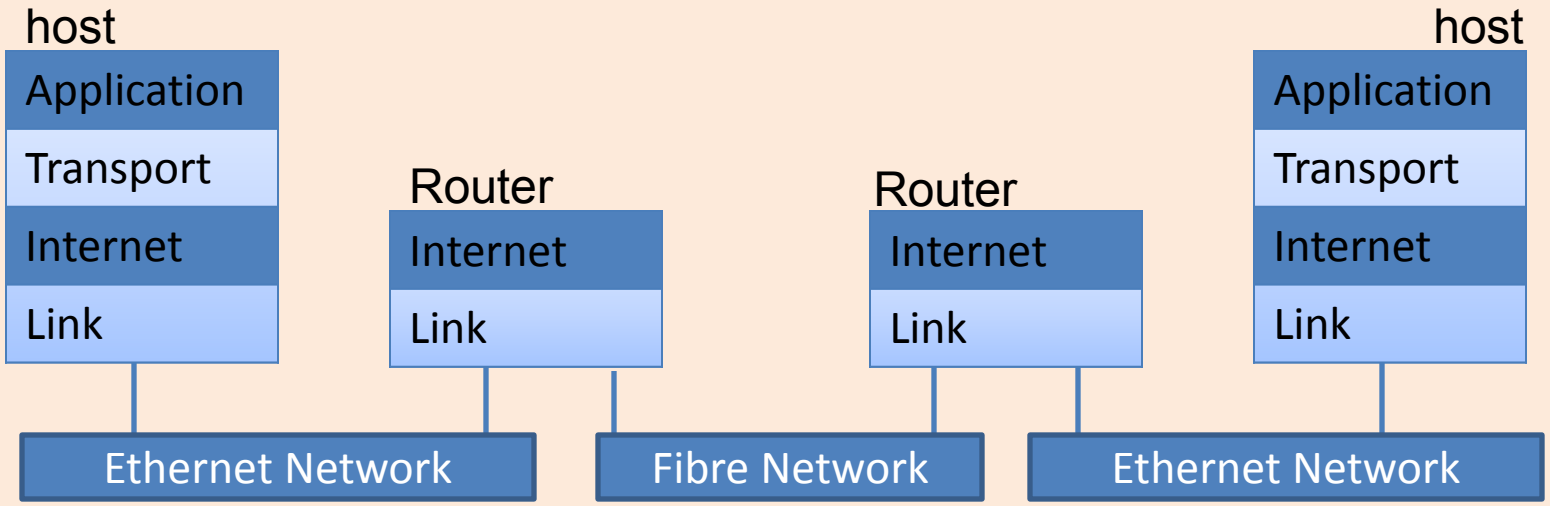
- Check IP header if packet destination is for this host. If yes, strip header and pass to Transport layer
- Otherwise forward packet (routing)

IPv4 Addresses & Domain Name Service



- IP addresses are 32 bit numbers often written in 4 octets: 128.171.10.13
- Each address is also split into two parts
  - Prefix is the network address
  - Suffix is the host address within that network
- Domain Name Servers provide a service that translates more meaningful names to IP addresses
  - Uhunix.hawaii.edu = 128.171.24.197
  - www2.hawaii.edu = 128.171.224.150

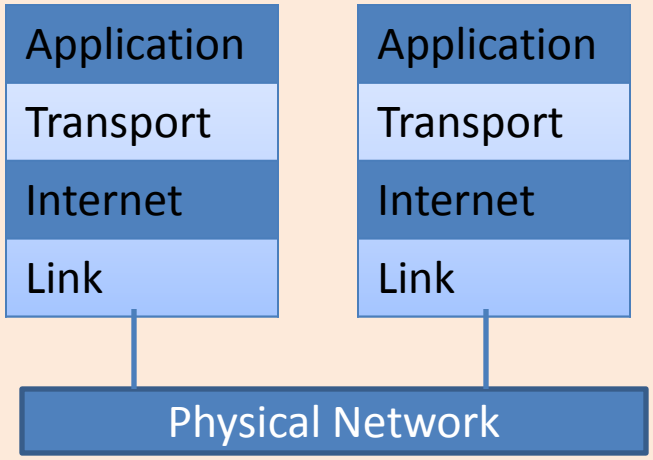
IPv4 & Inter-network Routing



For routers

- Examine destination IP address
- Look up routing tables to determine outgoing network
- Pass packet to link layer of that outgoing network
- Best effort delivery – no guarantees!

Transport Layer

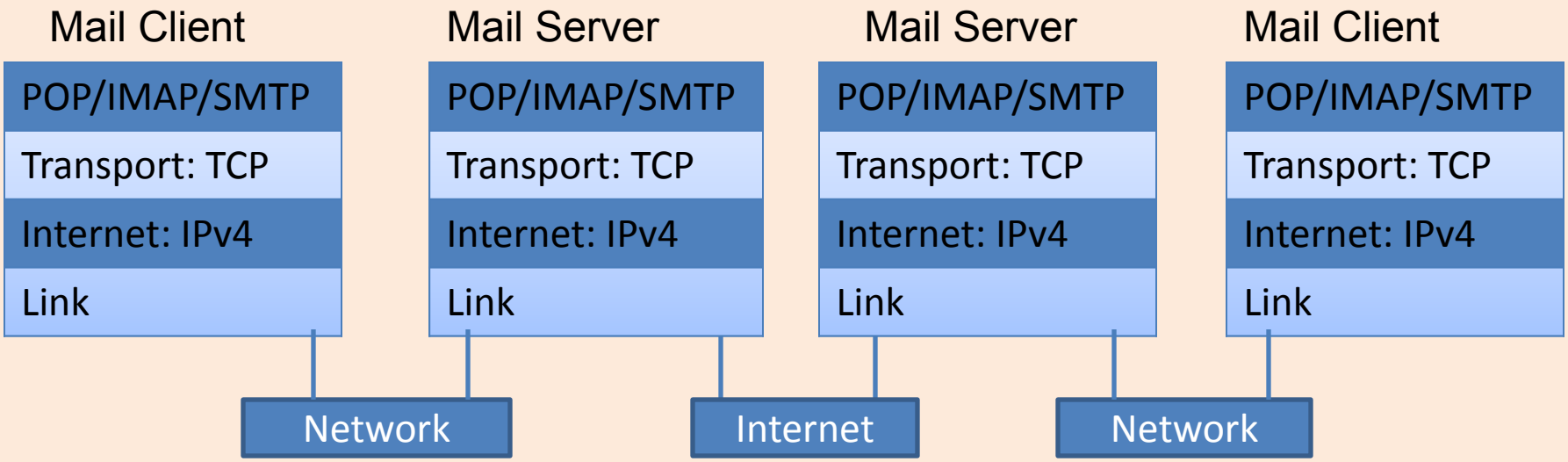


- Eg. TCP (connection-oriented), UDP
- End-to-end message transfer between hosts applications
- Each application on a host is associated with a port number
- IP address + port number will identify an application end-point

TCP provides a reliable communication channel between two host applications by addressing several issues

- Data packets arriving out of order
- Data packets are corrupted
- Same packets arriving more than once
- Some packets are lost/discarded
- Traffic congestion control

Applications: Email

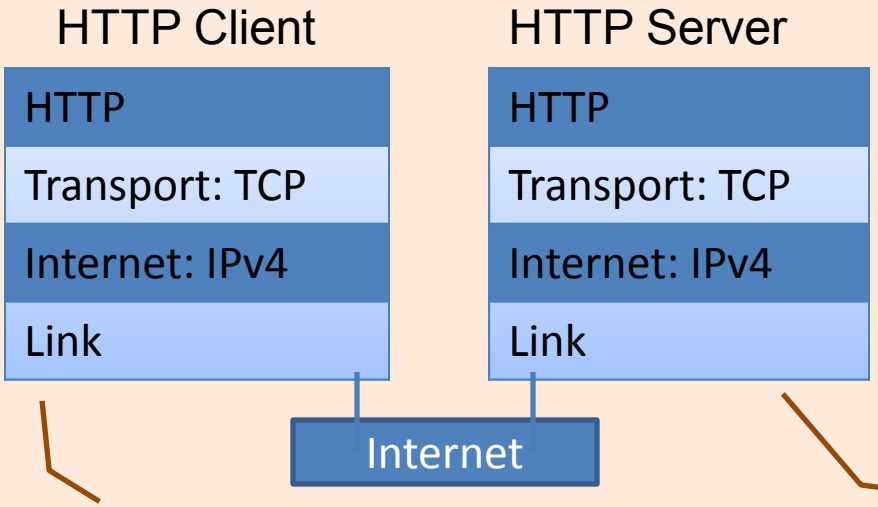


- Your email client program downloads incoming emails from mail server (imap.gmail.com pop.gmail.com)
- Outgoing emails are sent to mail server (smtp.gmail.com)
- Mail servers handle the routing of emails using SMTP protocol which operates on port 25 or 587
  - Lookup IP address of destination hostname in the email address using DNS
  - Relaying email as packets to that IP address

Sample Email Header

Delivered-To: strev@guhrelay.hawaii.edu
Received: by 10.58.145.6 with SMTP id sq6csp687725veb; Mon, 3 Sep 2012 20:39:01 -0700 (PDT)
Received: by 10.68.129.38 with SMTP id nt6mr43102232pbb.76.1346729940698; Mon, 03 Sep 2012 20:39:00 -0700 (PDT)
Return-Path: <postmaster@laulima.hawaii.edu>
Received: from mta11.its.hawaii.edu (mta11.its.hawaii.edu. [128.171.224.147]) by mx.google.com with ESMTPS id px6si25354378pbc.214.2012.09.03.20.38.53 (version=TLSv1/SSLv3 cipher=RC4-MD5); Mon, 03 Sep 2012 20:39:00 -0700 (PDT)
Received-SPF: pass (google.com: domain of postmaster@laulima.hawaii.edu designates 128.171.224.58 as permitted sender) client-ip=128.171.224.58;
Authentication-Results: mx.google.com; spf=pass (google.com: domain of postmaster@laulima.hawaii.edu designates 128.171.224.58 as permitted sender) smtp.mail=postmaster@laulima.hawaii.edu
MIME-version: 1.0
Content-type: multipart/mixed; boundary="Boundary_(ID_3RY8N2VbJHb4tH5siR1eww)"
Received: from pmx11.its.hawaii.edu (pmx11.its.hawaii.edu [128.171.224.58]) by mta11.its.hawaii.edu (Sun Java(tm) System Messaging Server 6.3-11.01 (built Feb 12 2010; 32bit)) with ESMTP id <0M9T0071I3GJ4F40@mta11.its.hawaii.edu>; Mon, 03 Sep 2012 17:38:45 -1000 (HST)
Received: from kuhi.its.hawaii.edu (kuhi.its.hawaii.edu [128.171.25.223]) by pmx11.its.hawaii.edu (Postfix) with ESMTP id E587118C023; Mon, 03 Sep 2012 17:38:42 -1000 (HST)
Received: from sak24.its.hawaii.edu (sak24.its.hawaii.edu [128.171.225.199]) by kuhi.its.hawaii.edu (8.12.10/8.12.6) with ESMTP id q843ccvH023430; Mon, 03 Sep 2012 17:38:38 -1000 (HST)
Date: Mon, 03 Sep 2012 17:38:33 -1000 (HST)
From: Dennis Streveler <strev@hawaii.edu>
Cc: "strev@hawaii.edu" <strev@hawaii.edu>
Message-id: <112987554.2310.1346729913602.JavaMail.sakai@sak24.its.hawaii.edu>
Subject: ICS 101 Help: Tuesday lecture -- Everything you THOUGHT you knew about NETWORKS and then some
X-Mailer: sakai-mailsender

Applications: HTTP



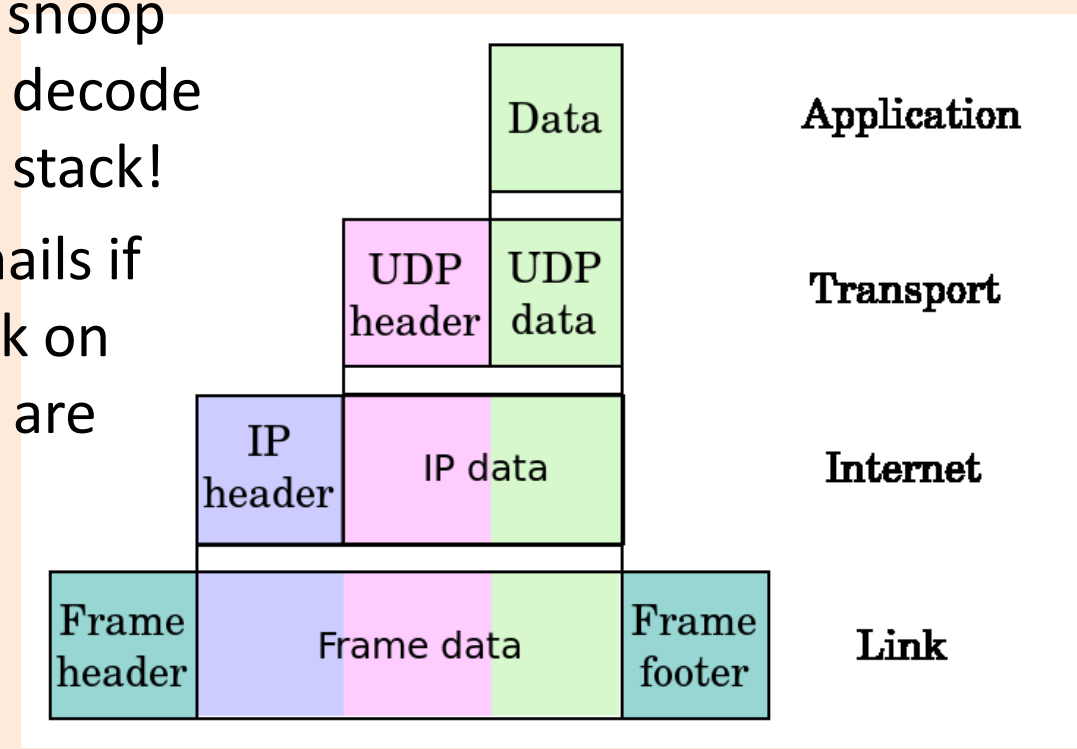
- Hyper-Text Transfer Protocol (port 80)
- Request-response protocol
- When http://www2.hawaii.edu/~lipyeow/index.html is entered into a web browser (http client)

```
GET /~lipyeow/index.html HTTP/1.1
host: www2.hawaii.edu
```

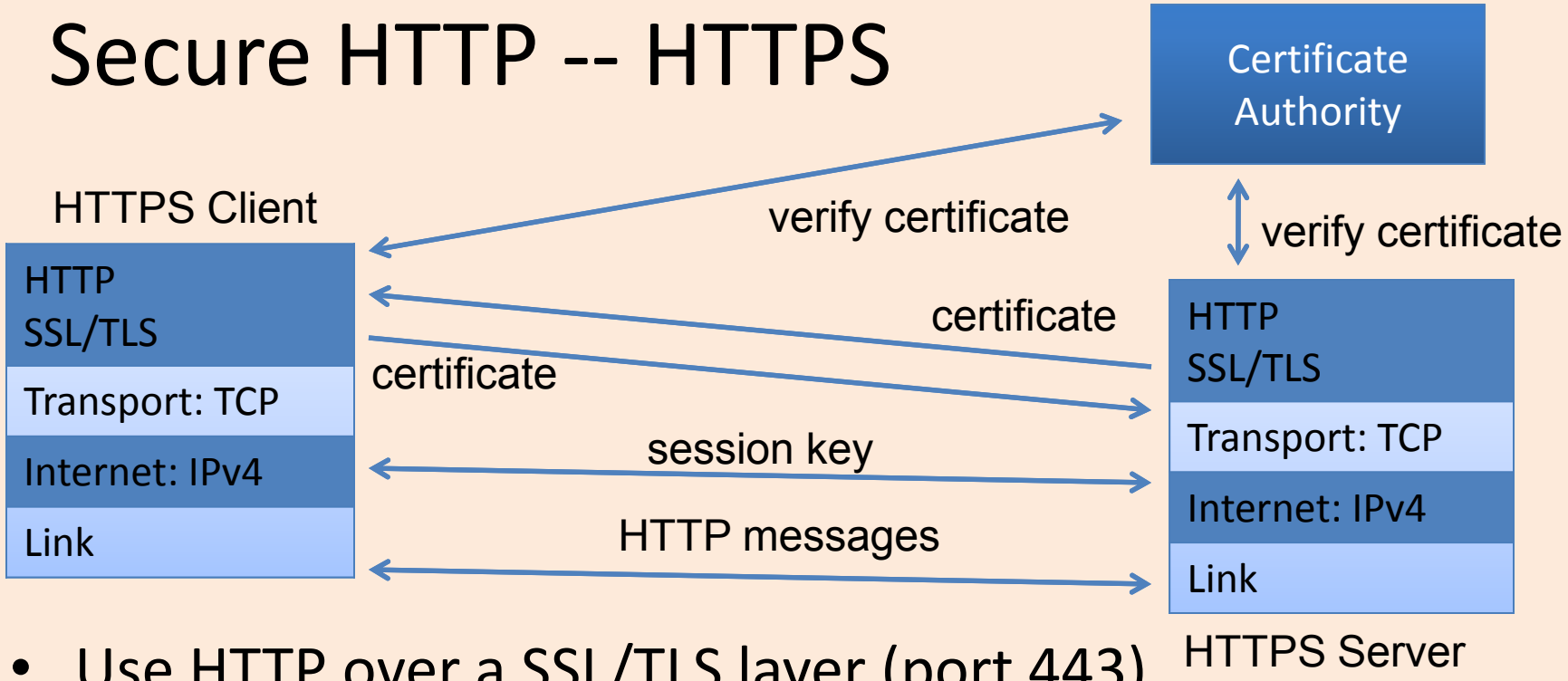
```
HTTP/1.1 200 OK
Date: Sun, 02 Sep 2012 00:35:40 GMT
Server: Apache
Last-Modified: Tue, 21 Aug 2012 01:27:18 GMT
ETag: "7d3e8-2950-4c7bc86e86980"
Accept-Ranges: bytes
Content-Length: 10576
Content-Type: text/html
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN"> <HTML> ...
```

Internet Security

- All data transmitted on the network using the protocols described thus far are in plaintext
- Anyone with access to the physical network link can snoop on the bit sequences and decode according to the protocol stack!
- Anyone can read your emails if he/she has access to a link on which your email packets are transmitted
- Use encrypted connections eg. SSL/TLS



Secure HTTP -- HTTPS



- Use HTTP over a SSL/TLS layer (port 443)
- Negotiate a stateful encrypted connection to carry the HTTP messages.
- Use a trusted 3rd party (CA) to verify identity
- Use public key handshake to establish a session key
- Encrypt subsequent messages using session key

Worksheet Questions

1. Packets are the unit of transfer between two communicating nodes. Name **two fields** in a packet format.
2. Recall the TCP/IP 4-layer model. Name one possible protocol/technology at the **link** layer.