ECE 435 – Network Engineering
Lecture 8

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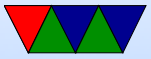
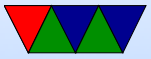
Announcements

- HW#3 due
- HW#4 will be posted



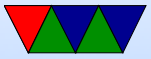
HW#2 C Review

- Mostly C issues
  - Time Wait
  - don't ignore compiler warnings!
  - The biggest issue if your browser isn't displaying things is the wrong Content-length:
    If you send less data than you say you will, it will wait forever for it, or else give a "connection reset" if you close the connection.
  - Be sure you read everything the browser is sending



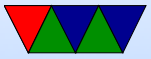
(Either big enough buffer, or repeat in loop reading it all). If you send a response before it is done sending it can confuse things. How can you hold an arbitrary size header? malloc()? Do you want to?

- Be sure to drop leading / in a URL
- sprintf() does not concatenate
  read() also does not concatenate
- ctime sticks an extra linefeed in things
- `sizeof()` operator. `char temp[1024];` what is `sizeof(temp)`? hint: it's not the same as `strlen()`
- have to read/write in loop if file sending is bigger than

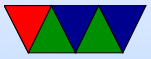


your file buffer

- just don't take addresses with ampersand randomly
- Can you use `strcat()` with binary file? why not? Can binary files have zeros?
- error checking!
- Many crashed if I requested the `README` file. Have to handle unexpected input from user. (in this case, no file extension)
- include proper header file. man can tell you
- Difference between ' ' and " "
- `sprintf()` 300 bytes into 100 byte array (snprintf?)

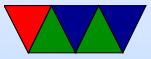


  - Only reading a small amount of bytes (100) when your file is bigger.
- Header and time format. There is a particular format, some browsers will ignore it, others not.
- Also depends on browser. For example, if have wrong content size, lynx just runs with it. wget tries forever. Other browsers give a connection reset error?
- Can use wget -S to see the headers you are sending
- If really HTTP/1.1 you should keep connection open, multiple requests on one connection.
- If you use firefox you'll see it might also request



favico.ico? Why? What should you return (assuming the file doesn't exist?) 404.

- Time wait
- Something Cool

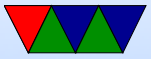


HW#4 Notes

- Decoding a hexdump

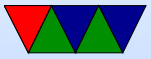
```
hexdump -C ece435_lec08.pdf
00000000  25 50 44 46 2d 31 2e 35  0a 25 d0 d4 c5 d8 0a 39  |%PDF-1.5.%.....9|
00000010  20 30 20 6f 62 6a 0a 3c  3c 0a 2f 4c 65 6e 67 74  | 0 obj.<<./Lengt|
00000020  68 20 33 37 33 20 20 20  20 20 20 20 0a 2f 46 69  |h 373       ./Fi|
00000030  6c 74 65 72 20 2f 46 6c  61 74 65 44 65 63 6f 64  |lter /FlateDecod|
00000040  65 0a 3e 3e 0a 73 74 72  65 61 6d 0a 78 da 9d 52  |e.>>.stream.x..R|
```

- First column is offset into the file or packet (usually in hex).
- The next set of columns are the raw bytes, in hex.
- The last column is the ASCII char equivalent of the raw data. a '.' often indicates non-printable ASCII.



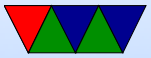
The Transport Layer

	OSI	TCP/IP
7	Application	Application
6	Presentation	
5	Session	
4	Transport	Transport
3	Network	Internet
2	Data Link	Host-to-network
1	Physical	Host-to-network

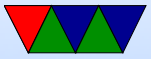


The Transport Layer

- Responsible for reliable point-to-point data transport independent of whatever lies beneath.
- Provide process-to-process connectivity, and per-segment error control and per-flow reliability, as well as rate control
- Can be more reliable than underlying network
- TCP (Transmission Protocol Layer)
  - connection oriented
  - stateful



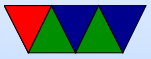
  - per-flow reliability and rate control
- UDP (User Datagram Protocol)
  - stateless
  - connectionless
- the “socket” is the API from old homework



The Transport Layer

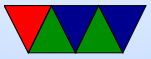
- Terminology: application = process, data-transfer-unit is a segment, traffic is a flow
- addressing – each process needs a unique ID. For internet, this is the "port" number (16-bit)
- Rate control
  - Flow control – between source and destination
  - Congestion control – between source and network

    None in link layer because only one hop?



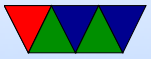
Can be done by sender or network

- Real time requirements – things like video and audio need extra info such as timestamp, loss rate, etc. So hard to do with raw TCP/UDP

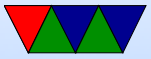


Unreliable, Connectionless – UDP

- User Datagram Protocol (RFC 768)
- Just an 8-byte header tacked onto the data packet
- No reliability, no rate control, stateless
  If you want these things you have to add them at higher layer
- Error control optional
- Why none of those things? All add overhead.
  - Used when want packets to get through quickly.
  - Don't care about re-transmits, better for real-time



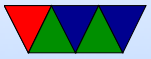
(VOIP, streaming?)
  - Easy to implement, for low-level stuff like bootp/dhcp
  - Good for broadcasting
- Provides process-to-process communication and per-segment error control
- Can send UDP packets to a destination without having to set up a connection first



UDP Header

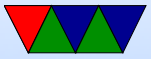
2 bytes	2 bytes
Source Port	Destination Port
Packet Length	Checksum

- 16-bits: source port (optional, says where it is coming from in case need to respond, 0 if unused)
- 16-bits: destination port
- 16-bits length (in bytes, includes the header, min 8) What's the maximum size?
- 16-bits checksum (optional, see below)
- data

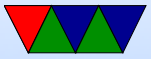


Port Numbers

- 16-bit, so 64k of them
- Can map to any you want, but there are certain well-known ones. Look in `/etc/services`. For example. WWW is 80/tcp. DNS is 53/udp
- On most operating systems, ports below 1024 require root (why?)
- Source/destination addr + source/destination port + protocol ID (TCP or UDP) is a socket pair (or 5-tuple) is 104 bits that uniquely identify a flow for IPv4. IPv6

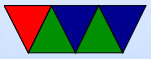


has a specific field for this



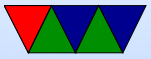
UDP checksum

- Find info on this in RFC768 and RFC1071
- If set to zero, ignored
- Receiver drops invalid checksums (does not request resend)
- Algorithm
  - 1s complement of sum all 16-bit words in header and payload
    padded with 0s to be multiple of 16-bits
  - Also added to the checksum is a 96-bit pseudo header



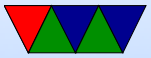
that has source IP, dest IP, (split in half) protocol, length (padded to 16). Enables receiver to catch problems with there to (delivered to wrong machine) – why could this be a problem?

- What happens if checksum is 0? entered as 0xffff
  What happens if it was 0xffff? Remember in ones complement 0xffff is negative zero.
- Checksum considered mandatory on IPv6 because IPv6 header not checksummed
- Why would you ever leave checksum out? Takes time to compute, might care about latency over errors [video?]

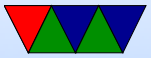


UDP checksum example

- ```
  0x0000:  8875 563d 2a80 0030 18ab 1c39 86dd 6002  .uV=*..0...9..‘.
  0x0010:  2618 0031 1140 2610 0048 0100 08da 0230  &..1.@&..H.....0
  0x0020:  18ff feab 1c39 2001 4860 4860 0000 0000  .....9..H‘H‘....
  0x0030:  0000 0000 8844
  UDP:
  e239 0035 0031 9c0e 8657  .....D.9.5.1...W
  0x0040:  0120 0001 0000 0000 0001 0377 7777 0465  ...........www.e
  0x0050:  7370 6e03 636f 6d00 0001 0001 0000 2910  spn.com.......).
  0x0060:  0000 0000 0000 00
  ```
- 16-bit sum of “virtual header” (two IPv6 addresses, protocol (0x0011) and length of udp packet/header (0x0031)) is 0x29f8c
- 16-bit sum of UDP header leaving off checksum is 0xe29f

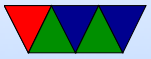

  ```

- 16-bit sum of UDP data is 0x2e1c0
- Add them get 0x6 63eb
- It's a 16-bit sum, so add 0x6 + 0x63eb = 0x63f1 ones complement is 0x9c0e, which matches the UDP checksum field



OS UDP

- When listening on UDP, sets up a queue
- Network stack decodes and gets UDP, finds port, looks to see if any processes listening on that port
- If so, adds to queue
- If not, sends an ICMP "port unreachable" error message
- All UDP messages to that port, no matter who sends them, end up in the same queue.

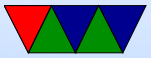


Writing UDP sockets code

- Use `SOCK_DGRAM` rather than `SOCK_STREAM`
- Can skip the listen/accept state, as no connection is there. Just receive the packets as they come in.

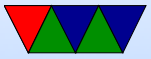
```
socket_fd = socket(AF_INET, SOCK_DGRAM, 0);
bind(socket_fd, (struct sockaddr *) &server_addr,
        sizeof(server_addr));
recvfrom(socket_fd,buffer,(BUFFER_SIZE-1),0,
        (struct sockaddr *) &client_addr, &client_len);
// use recvfrom as it stores the incoming address
sendto(socket_fd,buffer,strlen(buffer),0,
        (struct sockaddr *)&client_addr, client_len);
// sendto to respond, as we don't have a connection open

client:
        use sendto (again, no open connection)
```



Common UDP Services

- Obsolete: echo/discard/users/daytime/quote/chargen
- Nameserver
- bootp/tftp
- ntp (network time protocol)
- snmp



UDP real-time

- Real-Time Protocol (RFC1889)
- On top of UDP, multiplexes
- data streams
- timestamps