Introduction to TCP/IP

Heiko Holtkamp
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  - TCP/IP protocol architecture
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Summary

- An internet is more than a collection of networks interconnected by computers.
- Internetworking implies that the interconnected computers agree to onventions which make it possible to communicate with each other computer.
- In an internet, interconnections among networks are formed by computer called IP routers or IP gateways.
- Gateways route packets between networks by receiving them from one network and sending them to another.

Summary

- TCP/IP uses 32-bit binary addresses as universal machine identifiers
- The identifiers, called IP addresses, are devided into three primary classes (class A, B, C)
- To make such addresses easier for humans to understand, they are written in dotted decimal notation (e.g. 129.70.123.101)

- The fundamental service provided by TCP/IP's internet layer is a *connectionless, unreliable, best-effort* packet delivery system
- The internet Protocol (IP) formally specifies the format of internet packets (called *datagrams*) and informally embodies the ideas of connectionless delivery.

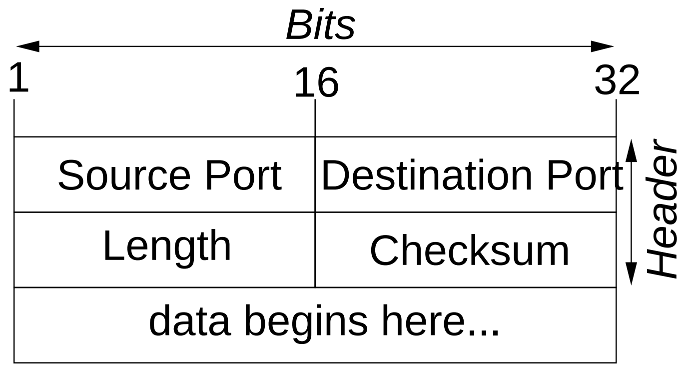
Transport Layer

The two most important protocols in the Transport Layer are the *Transmission Control Protocol (TCP)* and the *User Datagram Protocol (UDP)*.

- TCP is a reliable, connection-oriented, byte-stream protocol.
- UDP is an unreliable, connectionless protocol.

Transport Layer

- The User Datagram Protocol gives application programs direct access to a data delivery service (like IP).
- Unreliable means that there are no techniques in the protocol for verifying that the data reached the other end of the network correctly.
- UDP uses 16-bit numbers for the Source and Destination *Port*, to deliver data to the correct application process.



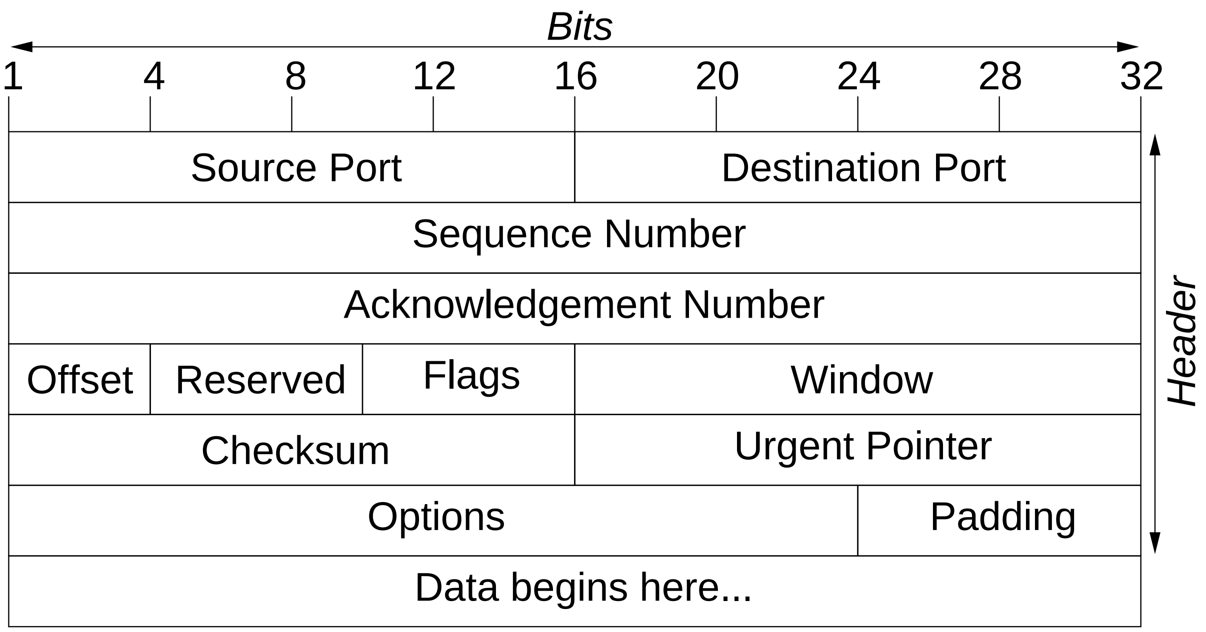
- Why is UDP used?
  - If the amount of data being transmitted is small, the overhead of creating connections and ensuring proper delivery may be greater than the work for retransmitting the data.
  - Sometimes applications use their own techniques for reliable data delivery so they don't require this service from the transport layer.

Transport Layer

What does it mean: *TCP is a reliable, connection-oriented, byte-stream protocol*?

- TCP provides reliability with a mechanism called *Positive Acknowledgement with Re-transmission (PAR)*.

- The data unit exchanged between communicating TCP modules is called a *segment*.



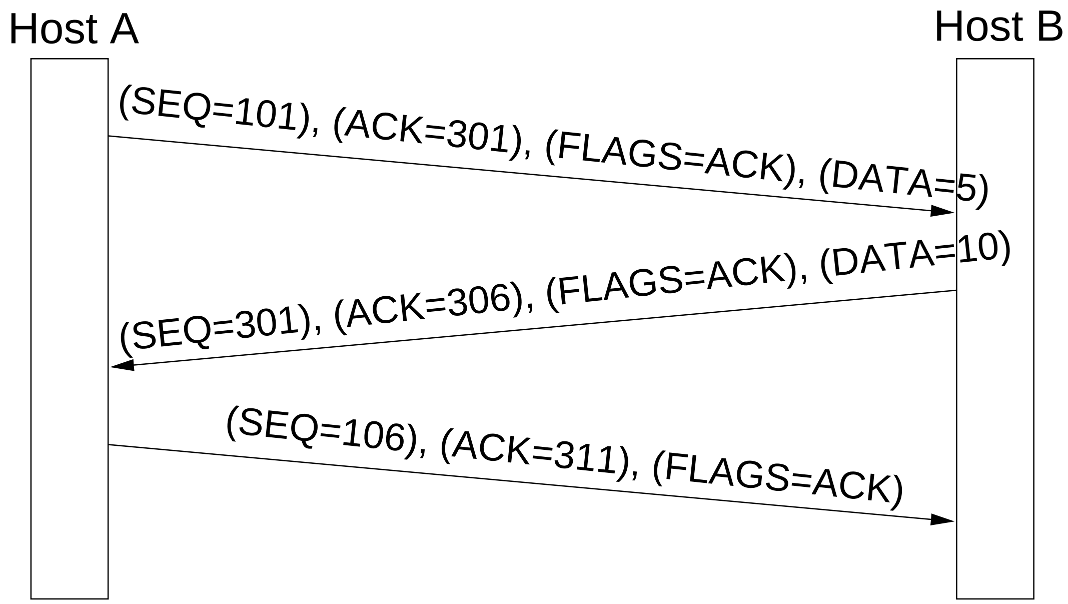
Transport Layer

- TCP is connection-oriented; it establishes a logical end-to-end connection between the two communicating hosts.
  - Control information, called a *handshake*, is exchanged between the two endpoints to establish a connection before data is transmitted.
  - The type of handshake used by TCP is called a *three-way handshake* because three segments are exchanged.

  - After this exchange Host A has the positive evidence that Host B is alive and ready to receive data.
  - When data transfer is finished Host A and Host B exchange a three-way handshake with segments with the FIN bit set to close the connection.

Transport Layer

- TCP views the data it sends as a continuous stream of bytes, not as independent packets.
- Therefore TCP takes care to maintain the sequence in which bytes are sent and received.
- The *Sequence Number* and *Acknowledgement Number* fields in the TCP segment header keep track of the bytes.



- TCP is also responsible for delivering data received from IP to the correct application.
- The application that the data is assumed for is identified by a 16-bit number called the *port number*.

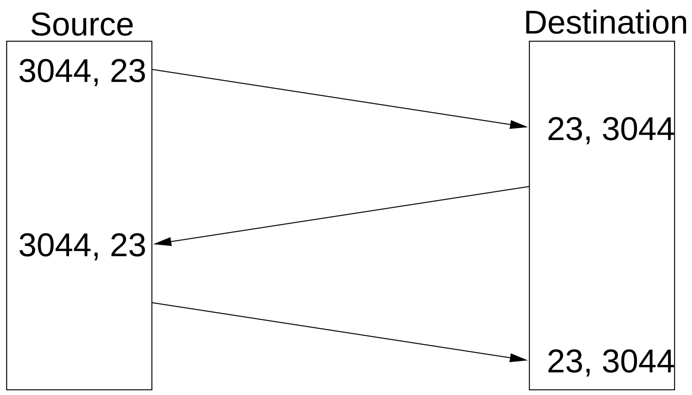
Transport Layer

Dont't forget to say . . . .

- TCP devides the 'application data stream' into pieces of a maximum size of 64 kByte (normally 1.500 Bytes).
- Each of this pieces is sent with its TCP header as an IP datagram.
- The destination TCP reconstructs the pieces back to the original data stream.

Transport Layer

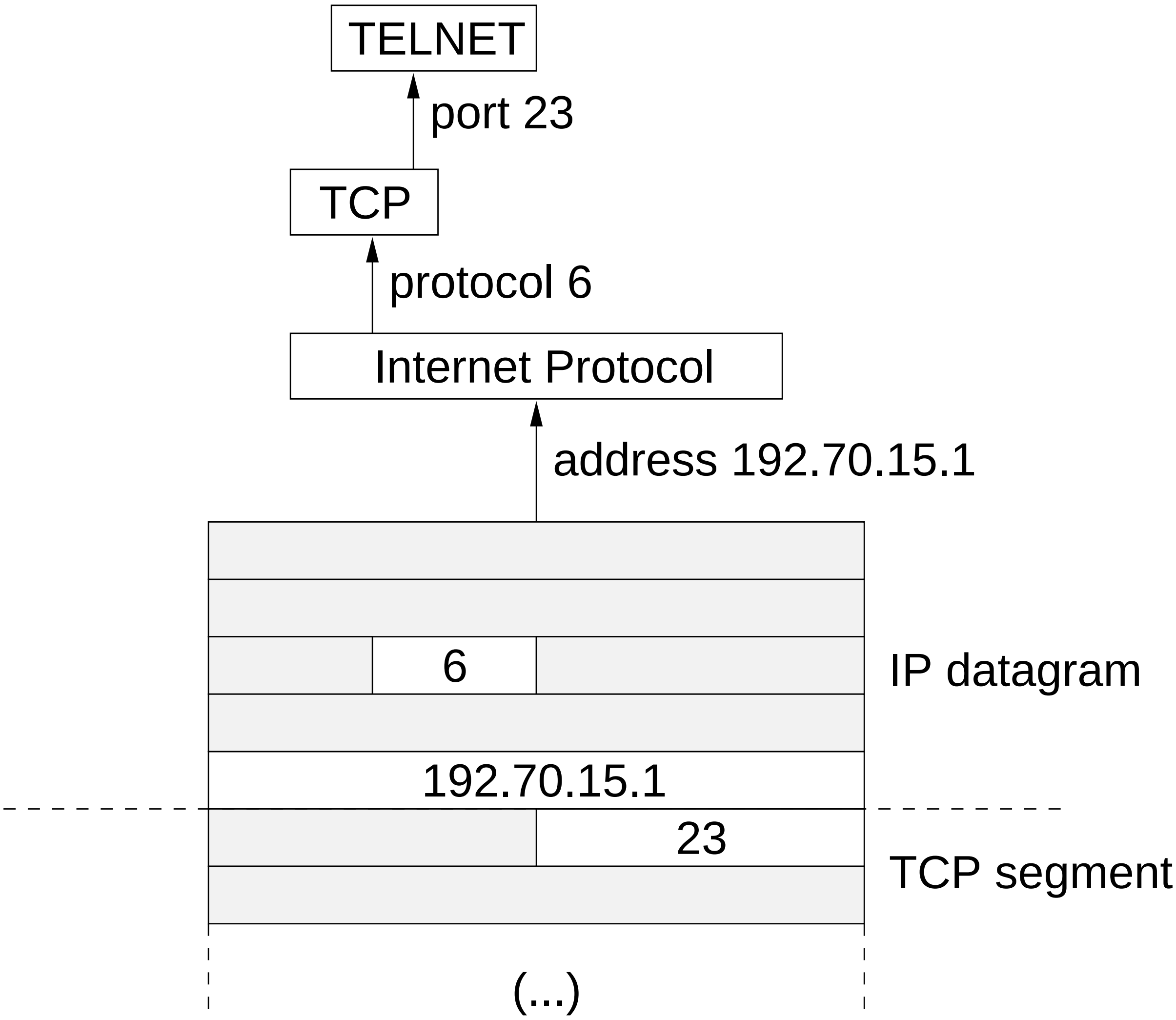
- Port numbers are used for addressing in the transport layer. As noted before, 'applications' are identified by 16-bit port numbers.
- The *source port number* identifies the process that send the data; the *destination port number* identifies the process that is to receive the data.
- On UNIX systems, port numbers are specified in `/etc/services`.
- Port numbers below 256 – also called *well-known ports* – are reserved for 'well-known services' (like FTP, SMTP and TELNET)
- There is a second type of port number for *dynamically-allocated ports*. They are assigned to processes when needed.
- Dynamically-assigned ports provide the flexibilty needed to support multiple users.
- It is the pair of port numbers, source and destination, that uniquely identifies each network connection.



Transport Layer

```
# Network services, Internet style, (Updated from RFC 1340)
#
echo            7/tcp
echo            7/udp
discard         9/tcp           sink null
discard         9/udp           sink null
systat          11/tcp          users
daytime         13/tcp
daytime         13/udp
netstat         15/tcp
qotd            17/tcp          quote
chargen         19/tcp          ttytst source
chargen         19/udp          ttytst source
ftp             21/tcp
telnet          23/tcp
smtp            25/tcp          mail
time            37/tcp          timserver
time            37/udp          timserver
nameserver      42/tcp          name            # IEN 116
whois           43/tcp          nicname
domain          53/tcp          nameserver      # name-domain server
domain          53/udp          nameserver
tftp            69/udp
finger          79/tcp
www             80/tcp          http    # WorldWideWeb HTTP
www             80/udp                  # HyperText Transfer Protocol
link            87/tcp          ttylink
hostnames       101/tcp         hostname        # usually from sri-nic
exec            512/tcp
login           513/tcp
who             513/udp         whod
shell           514/tcp         cmd             # no passwords used
syslog          514/udp
printer         515/tcp         spooler         # line printer spooler
talk            517/udp
ntalk           518/udp
route           520/udp         router routed   # RIP
```

Protocols, Ports and Sockets



Application Layer

At the top of the TCP/IP protocol architecture is the *Application Layer*. The application protocols run on top of TCP/IP. All the networking details are done by TCP and IP, so the application programs can treat network connections as if they were simple byte streams.

The most widely known applications are:

Telnet: Network Terminal Protocol; provides remote login over the network.

FTP: File Transfer Protocol; used to for interactive file transfer.

SMTP: Simple Mail Transfer Protocol; protocol for electronic mail.

DNS: Domain Name Service - Name Service; maps IP addresses to the names assigned to network devices.

NFS: Network File System; allows files to be shared by various hosts on the network.

HTTP: Hyper Text Transfer Protocol; the standard transfer protocol in the WWW.

But there are **many** other application protocols...

Where to get more information

- Holtkamp, H.: Einführung in TCP/IP
  (http://www.rvs.uni-bielefeld.de/∼heiko/tcpip)
- 'Request for Comments – RFCs'
  (http://www.internic.net/rfc)
- Comer D.E.: Computernetzwerke und Internets. Prentice Hall, München, 1998
  (see also http://www.netbook.cs.purdue.edu)
- Comer D.E., Stevens D.L.: Internetworking with TCP/IP:
  Volume I - Principles, Protocols, and Architecture
  Volume II - Design, Implementation, and Internals
  Prentice Hall, Englewood Cliffs, New Jersey, 1994/95
- Tanenbaum A.S.: Computer Networks. Prentice Hall, Upper Saddle River, New Jersey, 1996, 3rd ed.
  (see also http://www.prenhall.com/divisions/ptr/tanenbaum/book.html)
- Hunt C.: TCP/IP Network Administration. O'Reilly & Assoc., 1995
- Santifaller M.: TCP/IP and ONC/NFS - Internetworking in a UNIX Environment. Addison Wesley, Wokingham, England, 1994, 2nd ed.
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