Transport Layer / UDP

14-740: Fundamentals of Computer Networks
Bill Nace

Material from Computer Networking: A Top Down Approach. J.F. Kurose and K.W. Ross

Administrivia

- HW #1 will be posted shortly
- Mission: Learn to use network tools to gather information and for debugging
- Due in 2.5 weeks (18 Oct)
- Report due to Canvas

Administrivia

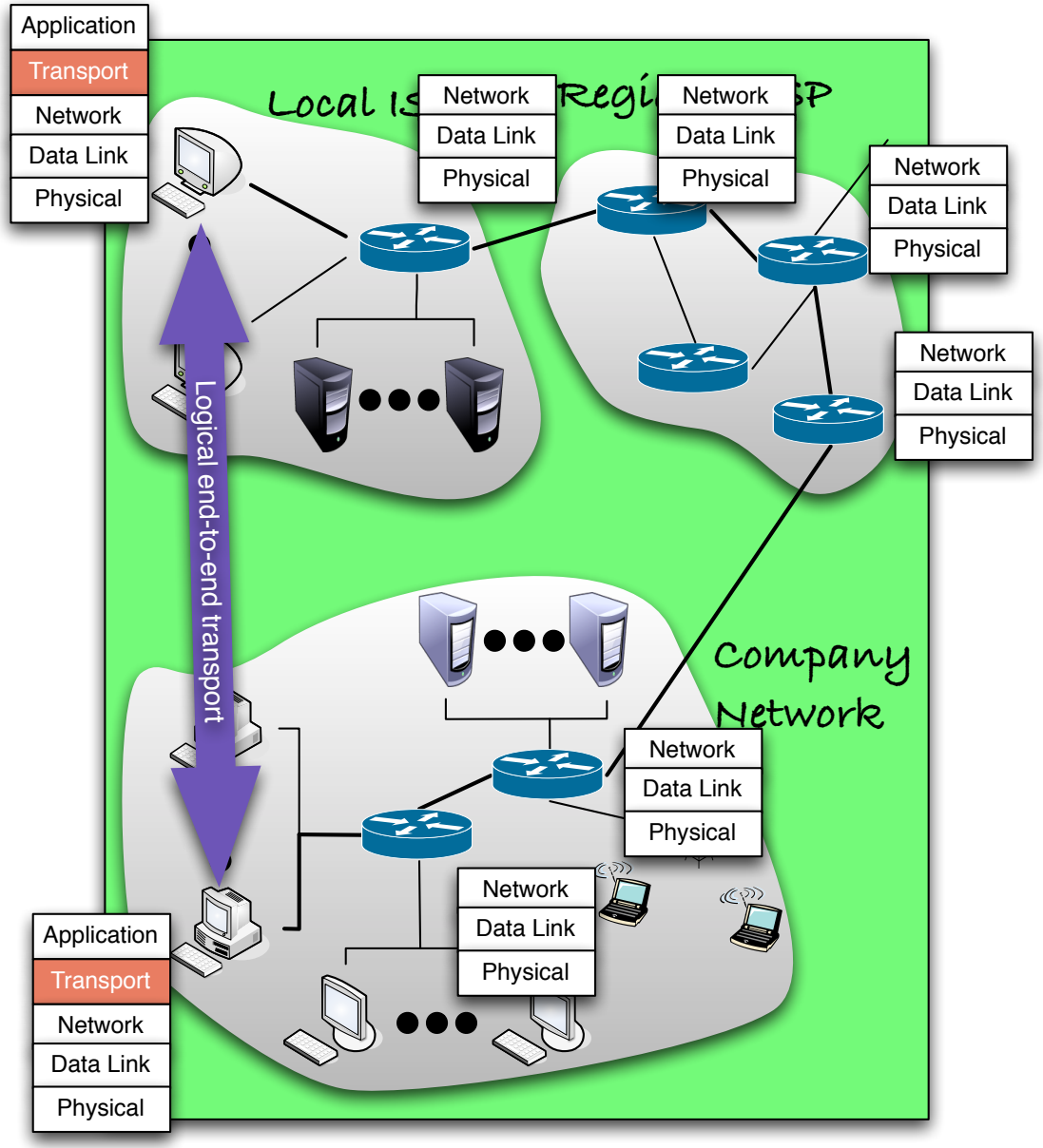
- Quiz next time!
- In class
  - Entire 1:20 available
- Closed book, no calculators
  - Equation sheet will be given if needed

traceroute

- Transport-layer services
- Connectionless transport: UDP

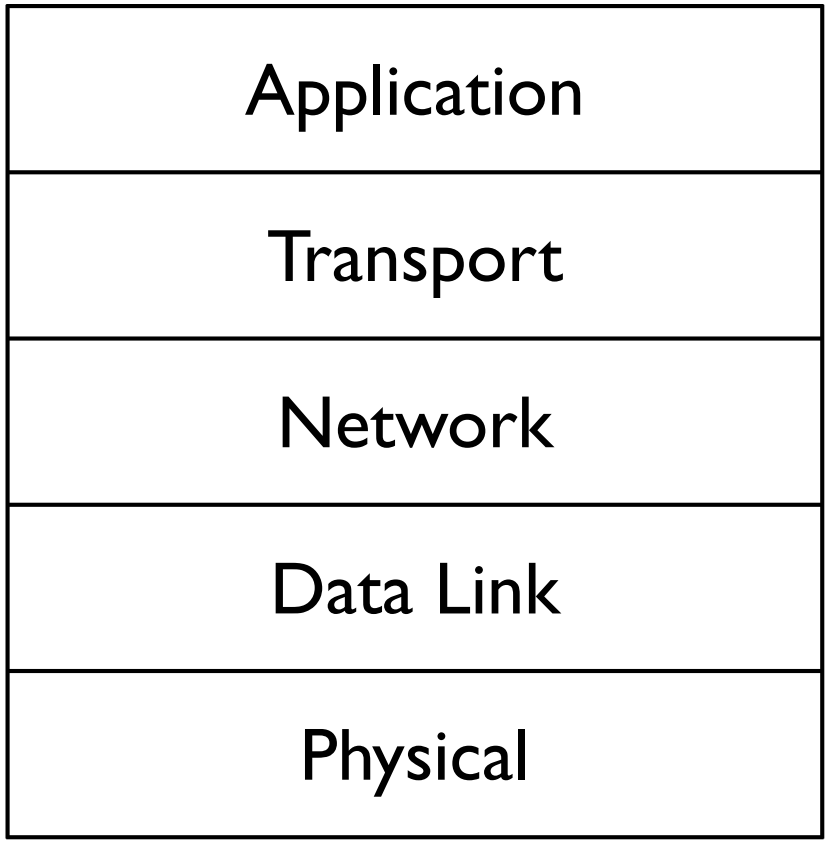
Transport services and protocols

- Mission: provide logical communication between applications running on different hosts
- Logical communication = as if the applications were directly connected



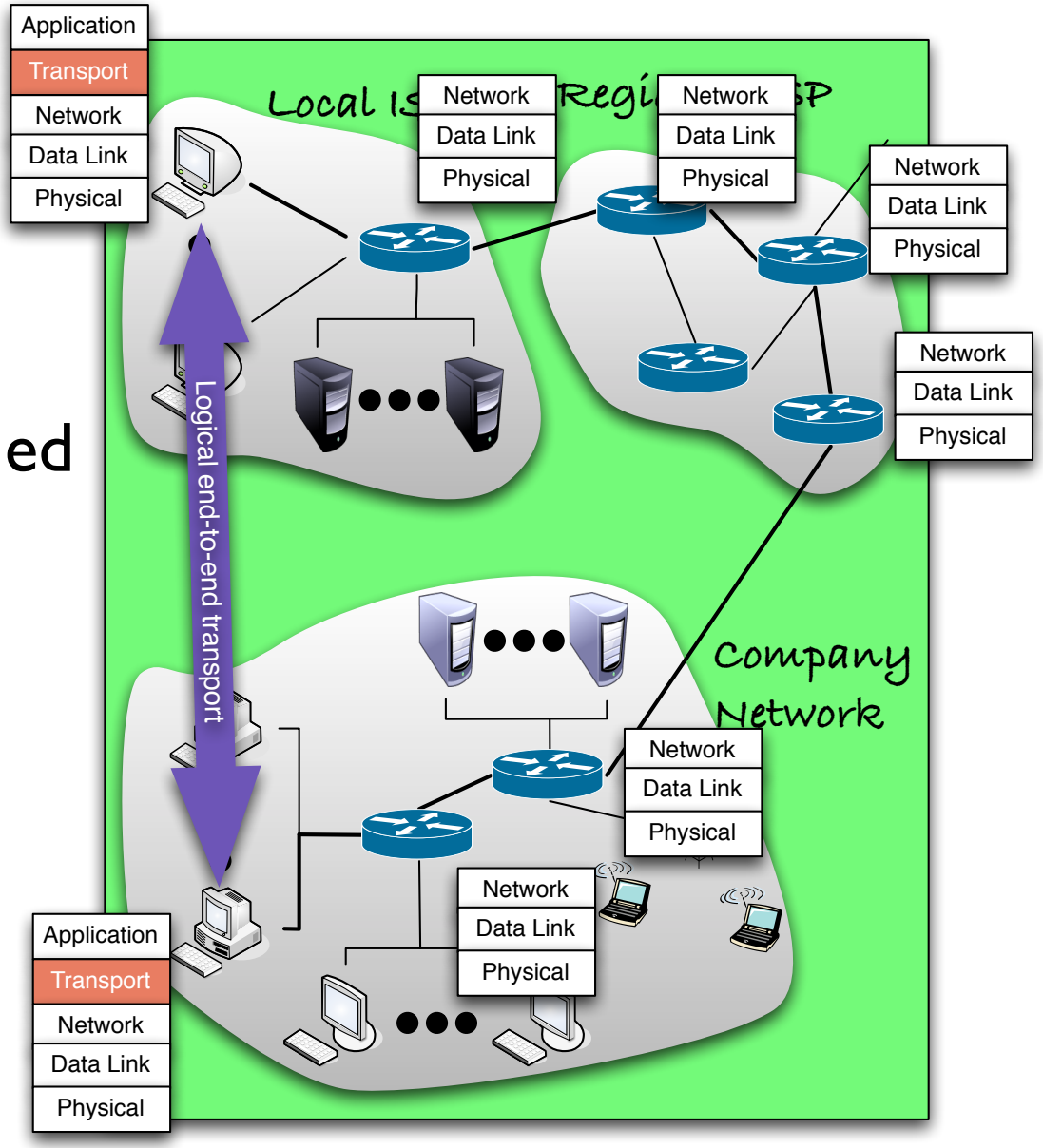
Using Network Services

- Network layer provides Internet Protocol (IP)
- Provides best-effort logical communication between hosts
  - ...of data provided in packets
- Does not provide reliability guarantees
  - or many others (timeliness, security, bandwidth, etc)



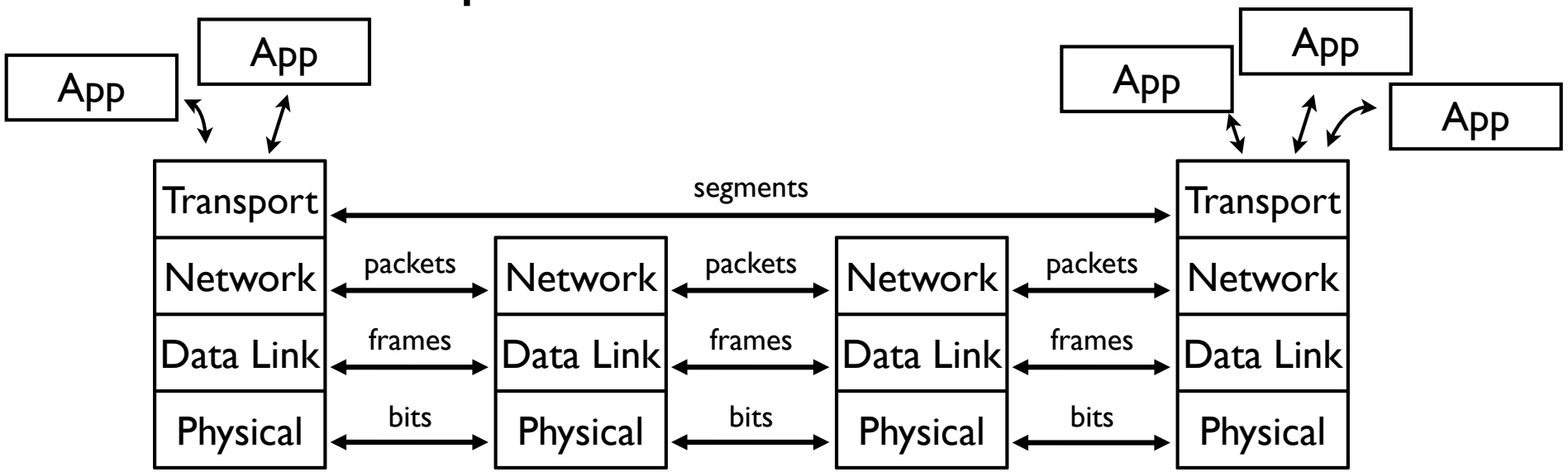
Key Functions

- Multiplex messages ...
  - ... and De-multiplex
- Breaking data into appropriate size pieces, called segments ...
  - ... and re-assembly
- Connection setup, state management, teardown (if necessary)
- TCP: reliability guarantees



Multiplexing

- End hosts have multiple applications running
- Messages are multiplexed at the sender
- ... de-multiplexed at the receiver



Port Numbers

- Multiplexing implies addressing
  - How do you know which application to deliver data to?
  - or which application sent the data?
- 16-bit unsigned number
  - Some applications use “well known” port numbers
  - Numbers assigned by IANA

"Well Known" Ports

TCP Examples

Port #	Application
22	SSH: Secure shell
25	SMTP: Email
80	HTTP
443	HTTPS

UDP Examples

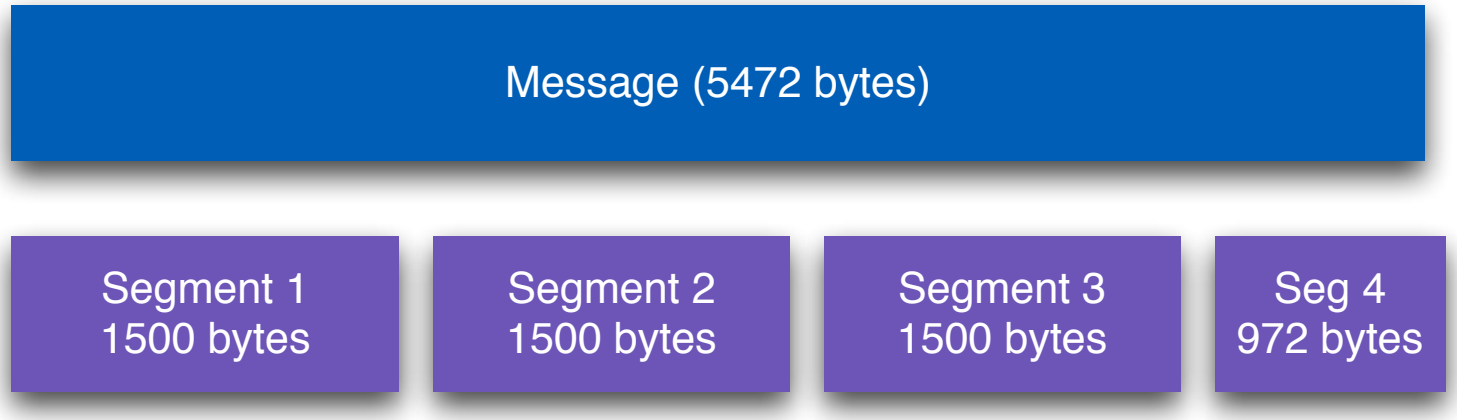
Port #	Application
53	DNS
161	SNMP: Net Mgmt
520	RIP: Routing
944	NFS: File System

Binding

- Port numbers are “bound” to an application
- Application tells Transport layer “I will listen on this port”
- Ephemeral ports often used where response is sent from a different port

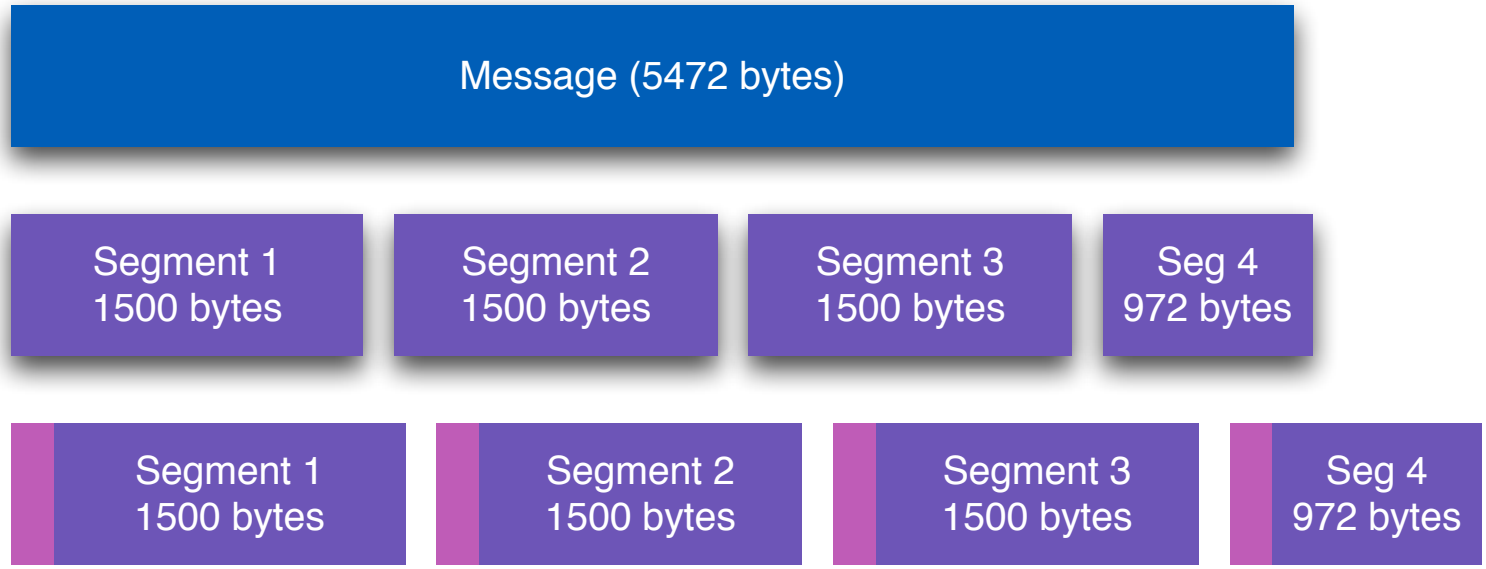
Segmentation

- Second responsibility of Transport layer
- Sender: Application provides “messages”
  - Broken into segments, passed to Network layer one-by-one
- Receiver: collects segments, reassembles into messages, passes to application layer



Headers

- Transport layer adds header with additional information (port numbers, ...)



traceroute

- Transport-layer services
- Connectionless transport: UDP

User Datagram Protocol

- “bare bones,” “no-frills” transport
- Defined in RFC 768
- “best-effort” service
  - segments may be lost
  - may be delivered out-of-order
- Connectionless
  - No handshaking
  - Each segment handled independently

Why?

- UDP requires no connection establishment, thus no additional delay
- Very simple: no state to maintain
- Segment header is small
- No congestion control
  - UDP can blast away as fast as desired

The Real "Why"

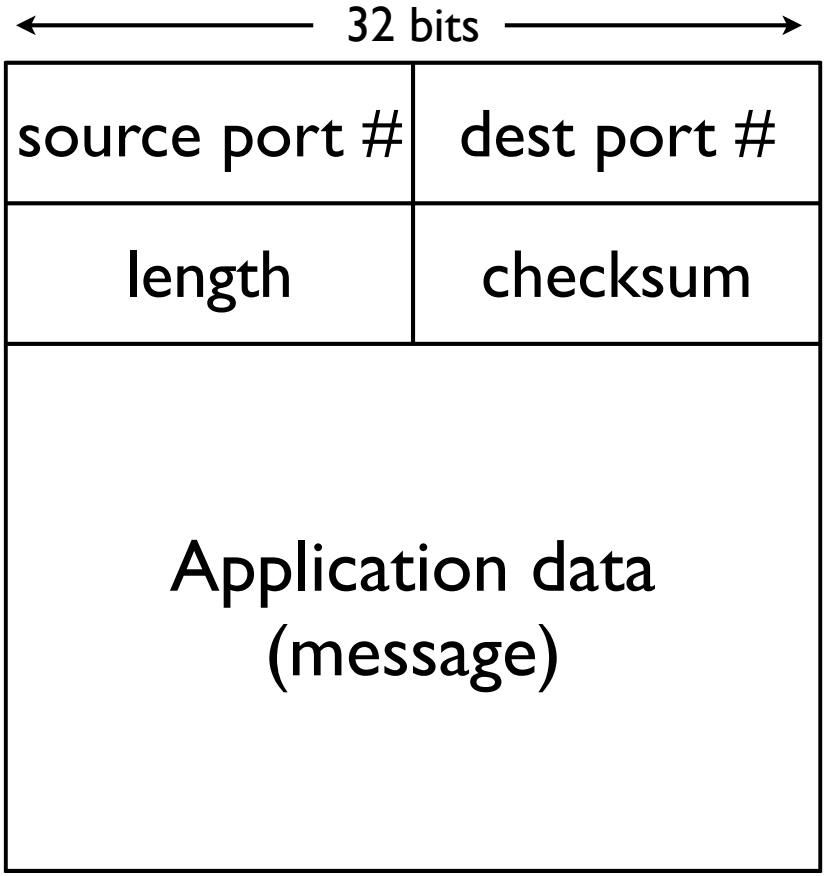
- Reliability requirements don't match TCP
  - TCP: If a segment is lost, it will be retransmitted
  - UDP: If a segment is lost, it should not be retransmitted
- Reliability can be added at app layer
  - application-specific error recovery
  - Perhaps proprietary algorithms

Uses

- Often used for streaming multimedia apps
  - Loss tolerant
  - Rate sensitive (timeliness)
- Used in DNS, SNMP

Segment Format

- Small header -- only 8 bytes
- Port numbers are 16 bits
  - Values of 0-65535
- Length is of entire segment, including header, measured in bytes
  - Segment could be 64KBytes



Checksum

- Goal: detect “errors” (flipped bits) in transmitted segment
- Algorithm selected for ease of implementation in software
  - See RFC 1071 for efficient implementation details
- End-to-end detection of bit errors

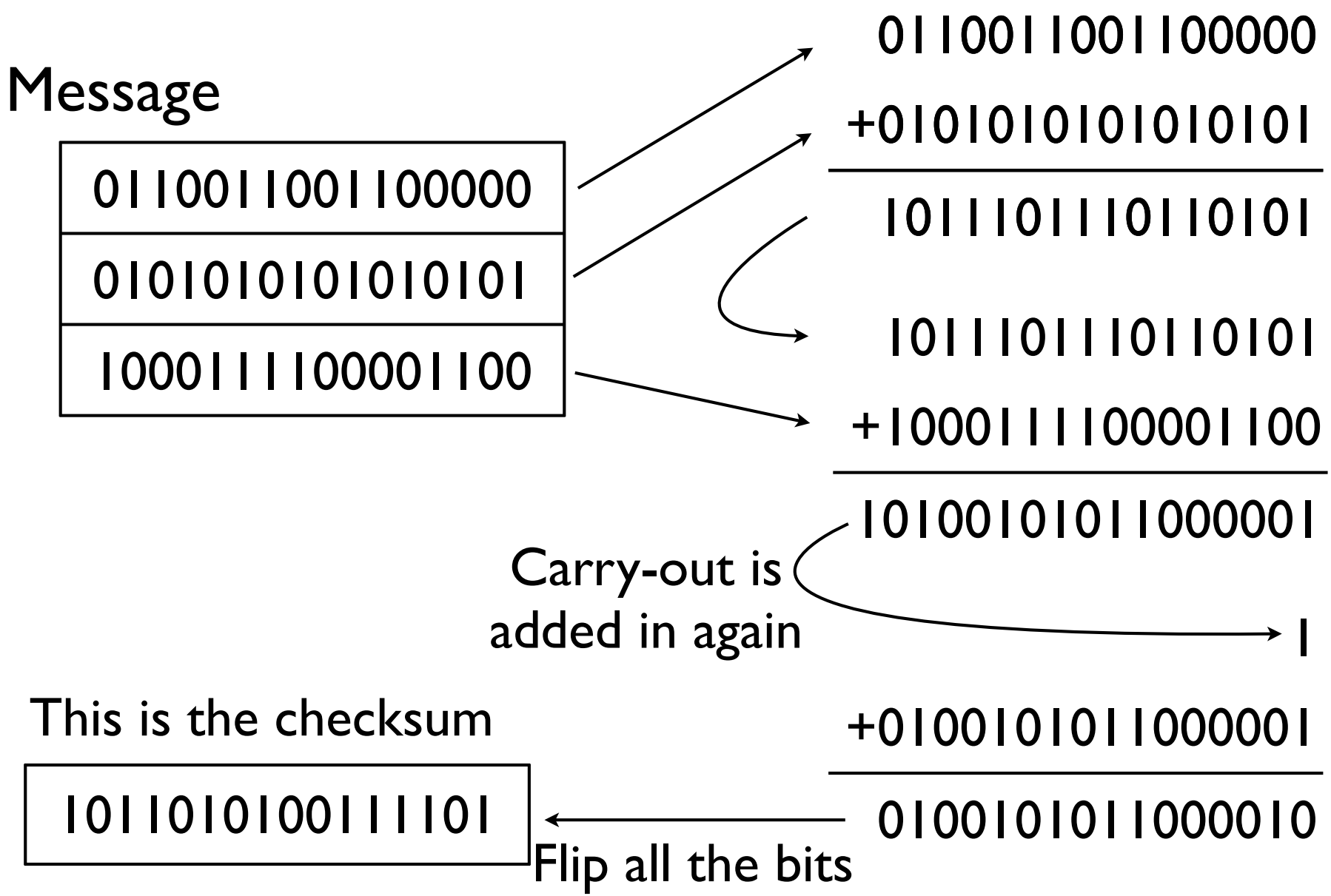
Checksum: Sender

- Sender:
  - Calculate the sum of all the 16-bit words in the segment
    - Wrap carry from output to input
  - Take the 1s complement (flip the bits)
  - Put the result in the UDP header

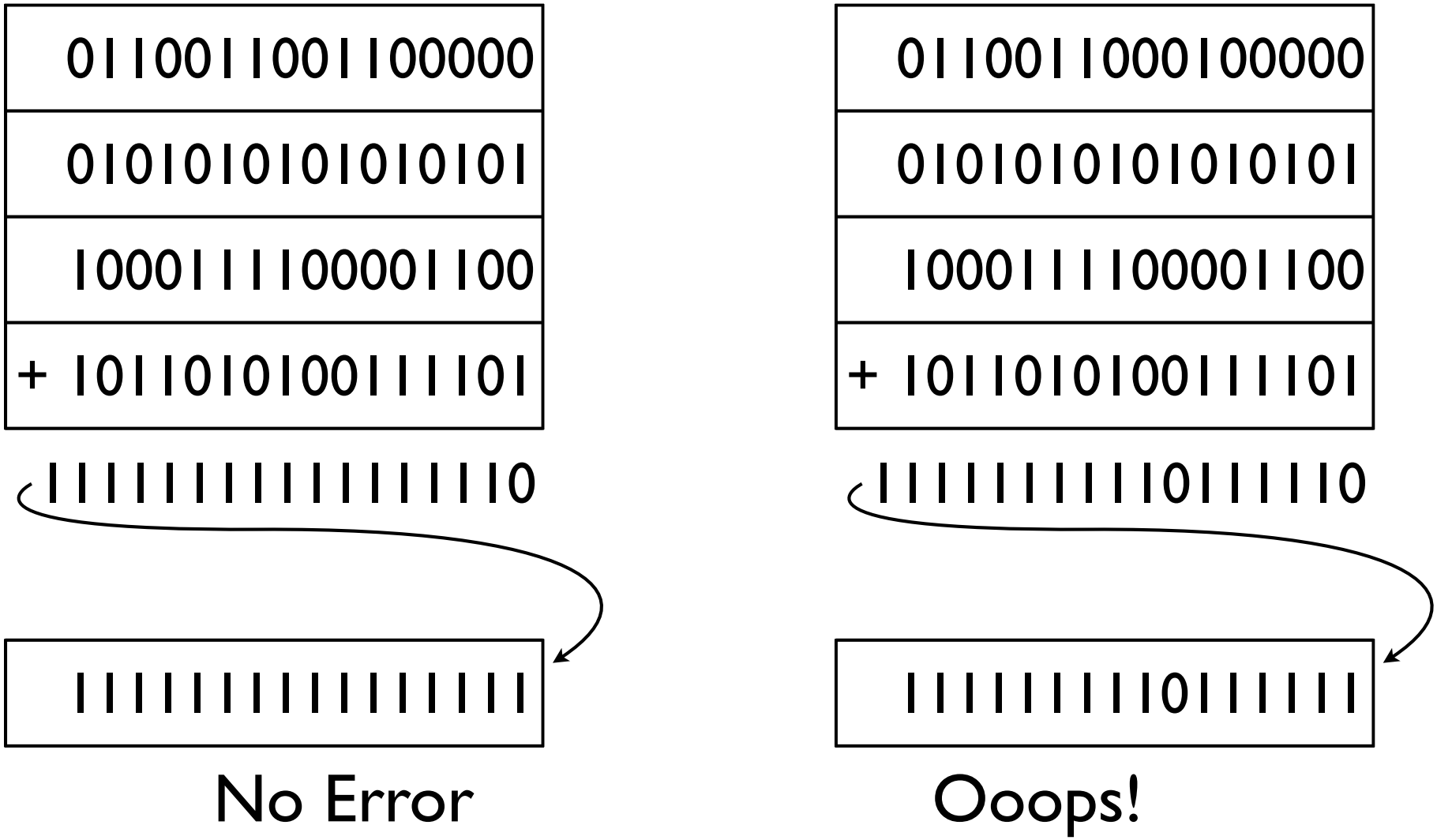
Checksum: Receiver

- Receiver:
  - Add segment contents, *including checksum,* as 16-bit words
    - Wrapping carry
  - Error if result is not all 1s

Checksum Example



Checksum check



Checksum good enough?

- Detects any single-bit flip
- Does not detect all 2-bit errors
- Designers decided this is “good enough”
  - Tradeoff of
    - Ease of implementation
    - Performance overhead
    - Strong enough for common case

Lesson Objectives

- Now, you should be able to:
  - describe the mission, scope, addressing mechanism, data types and responsibilities of the Transport Layer
  - explain UDP, including advantages/ disadvantages, segment format, and reliability assumptions
  - calculate the checksum of a UDP segment