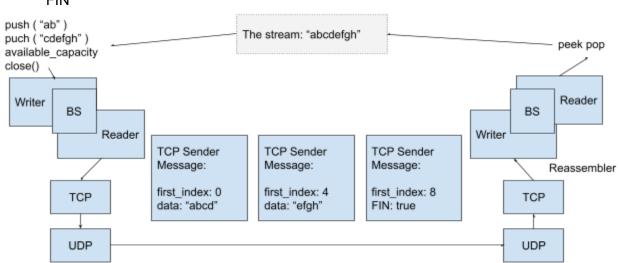
- Stacks of service abstraction
 - Short gets (DNS, DHCP) -> Use datagrams -> Internet Datagrams
 - Byte Stream –(TCP)--> User datagrams -> Internet Datagrams
 - Web requests/responses (HTTP) -> Byte Stream
 - Youtube/Wikipedia -> Web requests/responses
 - Email sending (SMTP) -> Byte Stream
 - Email receiving (IMAP) -> Byte Stream
- Multiplexing ByteStream
 - "u8 u8" (Which byte stream; what is the byte)
 - Any reading and writing of one byte would be actually two bytes, the first byte for which byte stream and the second for the actual byte
 - "u8 u8 {u8 u8 ... u8}" (which byte stream; size of payload; sequence of characters of the string chunk)
 - Any reading and writing of n bytes would be actually n + 2 bytes
 - Tagged byte stream: HTTP/2 | SPDY
- How to make ByteStream push idempotent?
 - TCP Sender Message

first_index data FIN

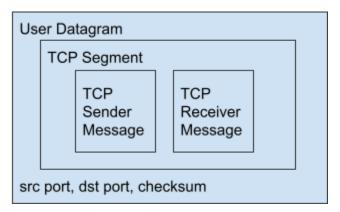


- This works for out-of-order or multiple deliveries. Since UDP has a checksum field, altered TCP Message would be ignored on the UDP layer.
- What if datagrams are missing?
 - How does the sender know that a datagram needs to be sent multiple times?
 - DNS/DHCP: if we don't receive an answer, then we retransmit. But such response/answer does not exist in `pushing` (void push())
- Acknowledgement
 - TCP Receiver Message
 - "A B C D E F G" each byte sent as a separate TCP sender message, and "D" is not received.

- "I got the sender message with first-index = 2, length = 1."
 - Valid but more work. There will be one receiver message for each sender message.
- "Got anything? Y/N. Next needed: #3."
 - Acknowledgements are accumulative, and that make life simpler.
- Give FIN flag a number: "A B C D E F G FIN".
 TCP Sender Message: {sequence number, data}
 TCP Receiver Message: {Next needed: optional<int>}
 and TCP Receiver Message {Next needed: optional(8)} would mean FIN is received.
- TCP Receiver Message: {Next needed: optional<int>; available capacity:int}
 - {Next needed: optional(3); available capacity: 2} ===
 Receiver wants to here about "DE".
 - "DE" is the **window**. (Red area in that picture of lab 1)
- TCP Receiver Message: {Ack no: optional<int>; window size: int}
- TCP Segment

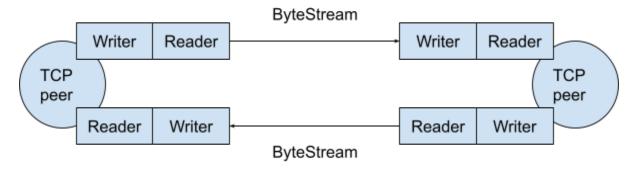
TCP Sender Message sequence no.; payload;

TCP Receiver Message ack no.: optional<int>; window size: int;

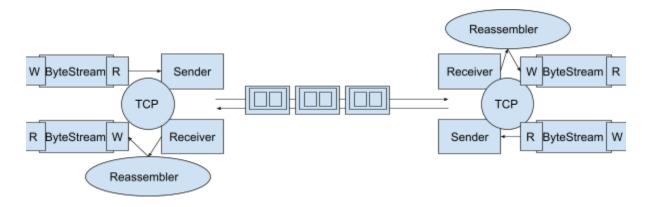


- This is the service abstraction that TCP is providing:

Service abstraction of ByteStream



- And this is what happens under the hood (and also what you will be implementing in the labs)



- Rules of TCP
 - Reply to any nonempty TCP Server Message