- Last time: “best effort” delivery as the service abstraction
    - Not delivered -> **timeout + retransmit**
    - Delivered n> 1 times -> **transform operations to be idempotent**
    - Delivered altered -> **checksum or crypto**
    - Delivered out of order -> **sequence number**
    - On top of this service abstraction, we can build:
        - VoIP
        - User Datagrams
        - VPN (IP-in-UDP/IP-in-IP/IPsec)
            - Q: How does Netflix determine where an IP address is actually from?
            - A: Netflix would look at the IP addresses provided by VPN services and ban those IP addresses.
- Short get: get(key) -> value
    - E.g. `host`: what is the IP address that corresponds to a host?
        - With package loss, it takes a longer time to reply, but would still give an answer
        - This service is “reliable” despite the fact that it is built on a unreliable “best effort” service abstraction

```C/C++
// Server
void recv ( const string& service ) {
      UDPSocket sock;
      sock.bind ( Address (“0”, service) );
      Address source (“0”);
      string payload;
      while (true) {
            sock.recv( source, payload);
            cout << “Message from” << source.to_string() << “: “
      << payload << endl;
            if (payload == "best_class_ever" ) {
                  sock.sendto( source, "EE180");
            }
      }
}
```

C/C++

```
// Sender
void run( const string& host, const string& service, const
string& query) {
      UDPSocket sock;
      sock.set_blocking( false );
      Address source ("0");
      string answer;

      // retransmit the query (with a small timeout), until there
is a reply
      do {
            sock.sendto(Address(host, service), query);
            this_thread::sleep_for(seconds(1));
            sock.recv(source, answer);
            if (answer.empty()) {
                  cerr << "No reply, retransmitting" << endl;
            }
      } while (answer.empty())

      cout << "Got reply to " << query << ": " << answer << endl;
}
```

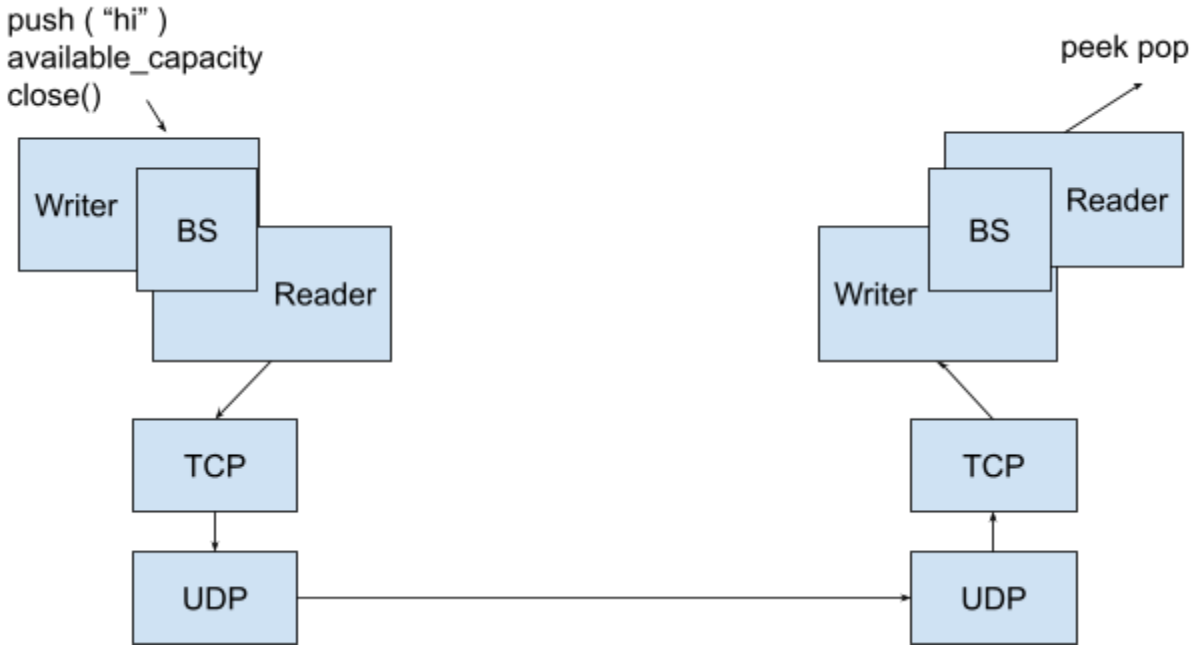
    - By doing this, we implement a “reliable” service on top of an “unreliable” service abstraction, and this is also how many real-word reliable services are built (e.g. `host`).
        - And also: Domain Name System (DNS): what is the IP address of an internet domain name?
        - DHCP (Dynamic Host Configuration Protocol): what is the IP address I am supposed to use?
- Set: (e.g. set the back door open)
    - Both short get and set (the back door open), you could say how ever many times you want and it does not change the ending state
    - But for `` `pop(7)` ``, `` `push(“hi”)` ``, it matters how many times you say it.
    - Idempotent: doing one time or more than one time does not change the ending state (GET PUT). The strategy we used above works for something idempotent, but not for non-idempotent action
- Do a non-idempotent operation (POST):
      By having a set of launched missiles, we make launch_missle idempotent

C/C++

```
// Server
void launch_missle() {
      cout << "Launching one missle" << endl;
}

void recv ( const string& service ) {
      unordered_set<uint64_t> launched_missle;
      UDPSocket sock;
      sock.bind ( Address (“0”, service) );
      Address source (“0”);
      string payload;
      while (true) {
            sock.recv( source, payload);
            cout << “Message from” << source.to_string() << “: “
            << payload << endl;
            if (payload == "best_class_ever" ) {
                  sock.sendto(source, "EE180");
            } else if (payload == "launch_one_missle" + missle_id
            ) {
                  if (missle_id not in launched_missle ) {
                        launch_missle();
                        launched_missle.insert(missle_id);
                  }
                  sock.sendto(source, "ack");
            }
      }
}
```

- ByteStream: push, pop, peek needs to be transformed into idempotent operations, and this is achieved by **TCP**



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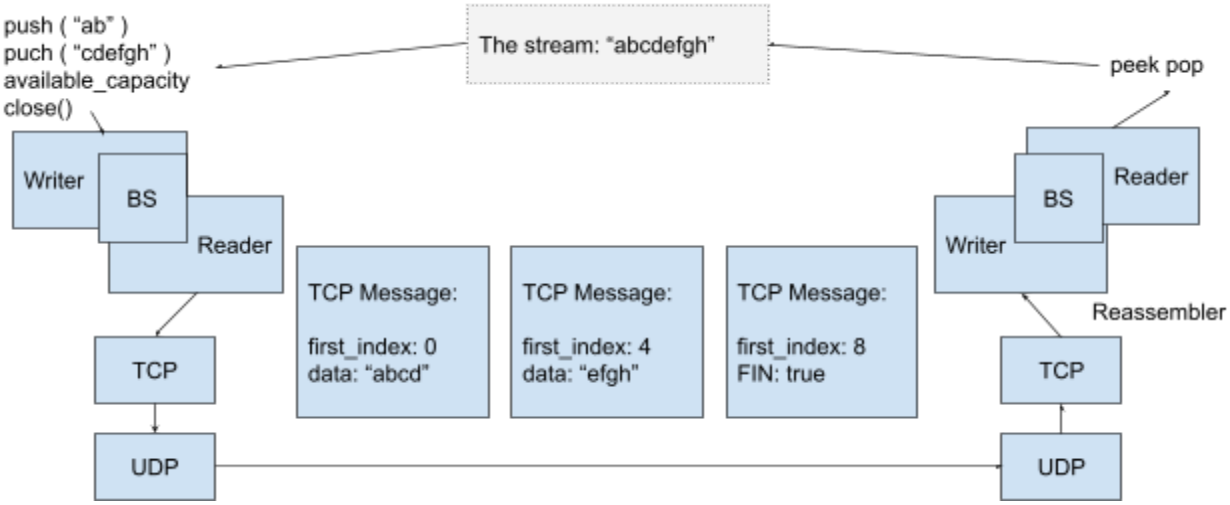
- What should be in the TCP Sender message to make these operations idempotent?
  - `push (“abcd”)` works iff each message is delivered exactly once
  - `push(“abcd”) + message unique id`, but the sender needs to keep a set of any message sent
  - Create a reassembler, `first_index: 0, data: “abcd”` `first_index: 4, data: “efgh”, `first_index = 8, FIN=true`



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