Static analysis for API error detection in IoT devices

Tapioca: a library for reasoning about web requests at compile-time

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Contents

Motivation

Errors in device communication

nest

Who will notice?

- Many IoT devices have no user-facing display

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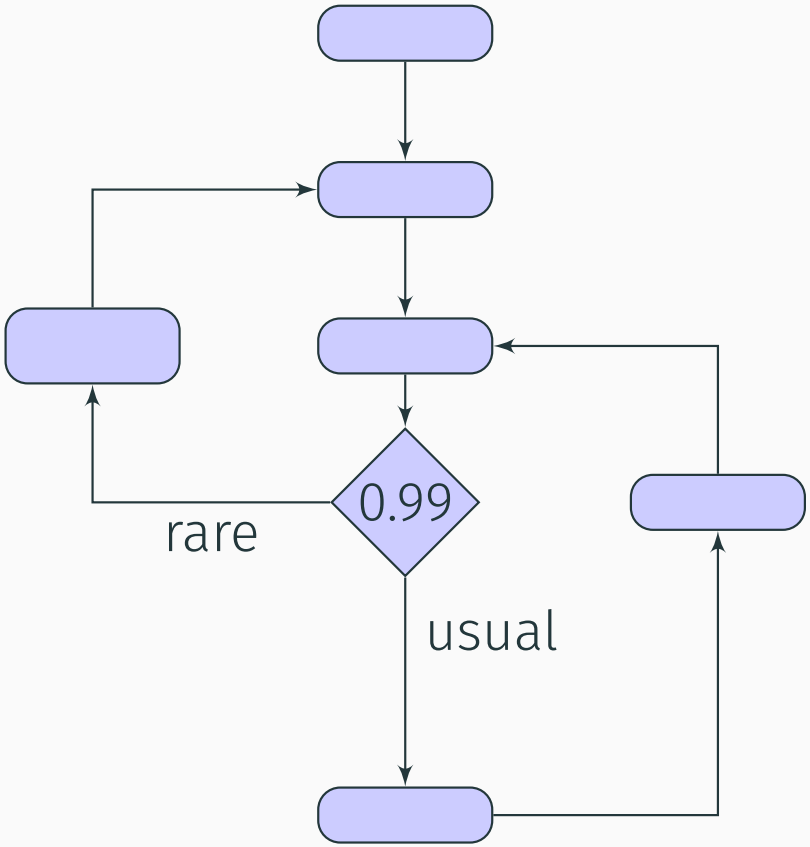
Examples

- Nest thermostat looking up local weather on third-party API
- Communication with a cross-vendor IoT device ‘bridge’

Test coverage?

- So? Just test it, right?



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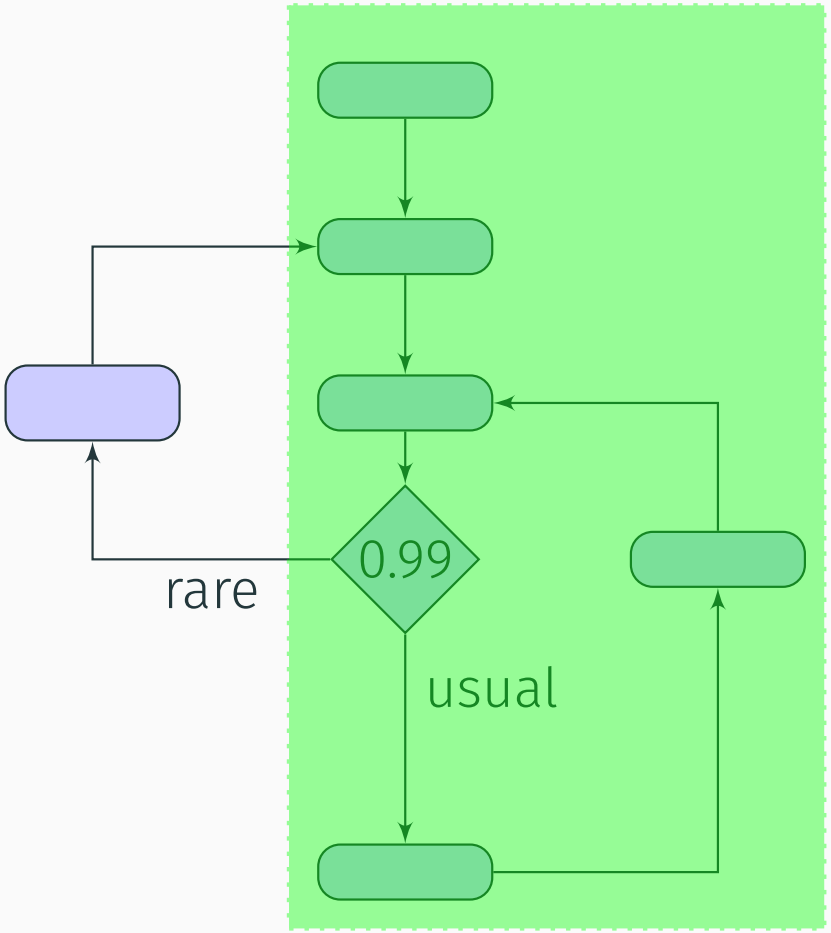

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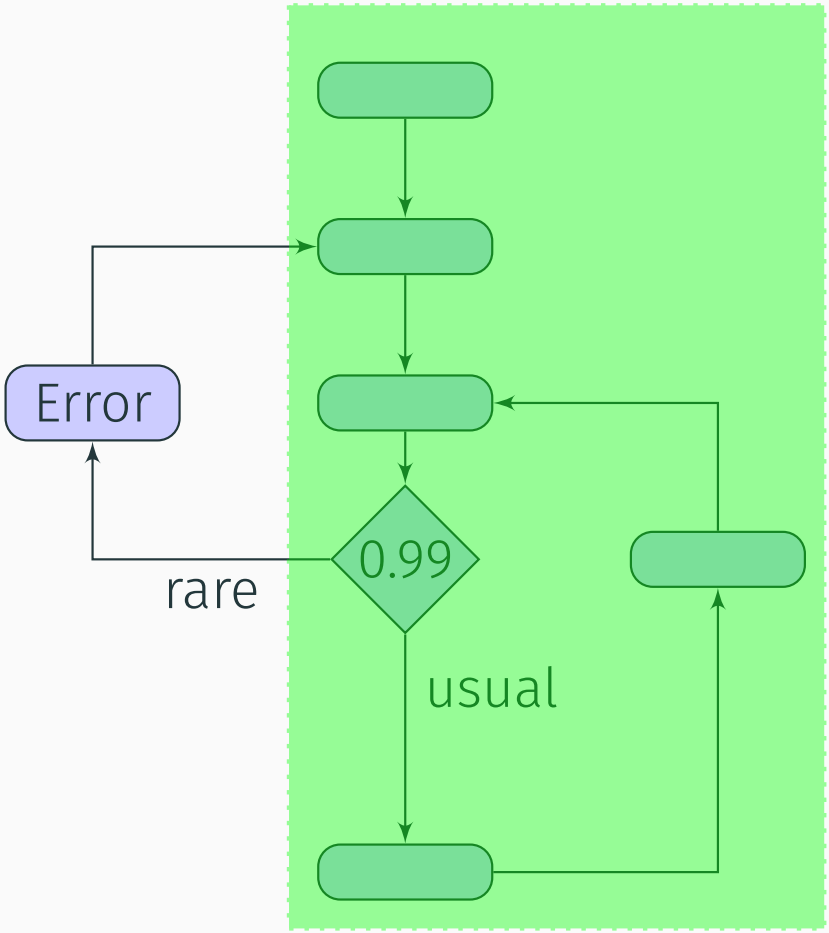

Server logging?

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- Not preventative

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- Hard, expensive, specialised
- Some research into extending to web services/REST
- But nothing available to the application developer today

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Not very promising: *surely* this can be avoided?

REpresentational State Transfer

REST: a stateless ’app’ model for the web

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- Resource available at its own URI
- Resource representation may be any hypermedia (HTML, JPEG, ...)
- HTTP methods have different semantics, idempotency

REST: RPC-ish over JSON

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- JSON resource representation: `{"foobars": [{"id": 42}]}`
- HTTP verbs have specialised semantics for collection/entity

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Serialisation of request bodies, query/path params is similarly problematic.

Idea: bring REST semantics ‘into’ the (client) language

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Despite their names, both checkers are really features of Rust’s type system.

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- Static: types inferred and verified at compile-time
  - idea: types for components of requests, responses
- Strong: invoked methods must be implemented for that type
  - resp. fields on that `struct`, etc.
  - idea: `enum` variant for each response status code

Affine (theory)

A whirlwind introduction

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  - useful for modelling external resources: I/O, locks, ...
  - idea: REST resources too?

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Result: no dangling pointers, double-frees, uses-after-free; memory leaks avoided; all without expensive GC and at compile-time.

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With this and similar models, we ‘tell’ the compiler how to check for invalid API use.

Okay… but what's invalid use?

OpenAPI Initiative's specification (OAS) allows YAML schema for REST API description

Okay… but what's invalid use?

OpenAPI Initiative's specification (OAS) allows YAML schema for REST API description:

```yaml
/addresses:
  summary: Address book endpoint
  get:
    description: List addresses in user's address book
    responses:
      200:
        description: List of addresses
        content:
          application/json:
            schema:
              type: array
              items:
                $ref: '#/definitions/Address'
  post:
    description: Add a new address
    requestBody:
      $ref: '#/definitions/Address'
    responses:
      405:
        description: Not implemented
```

Translating types

Map REST schema types to Rust types

Translating types

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```rust
struct Address {
    house_no: i32,
    street: String,
    postcode: String,
    country: String,
}

enum OkBody {
    Status200(Vec<Address>),
    // ...
    UnspecifiedCode(String),
    MalformedJson(String),
}

// ...

type ResponseBody = Result<OkBody, ErrBody>;
```

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```
let provisioned_id = ResourceId_name::from_static("...");

// or:
let response = addresses::post(&address, &auth);
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// then:
addresses__name_::get(&discovered_id, &auth);
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// compile error - use after move:
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Tapioca

Code generation

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- Expanded in-place at compile-time
- A ‘typed HTTP client’ generated under the module `name`
- Types correspond to definitions in the provided OAS schema

User code

```
#[macro_use]
extern crate tapioca;

infer_api!(httpbin,
    "https://raw.githubusercontent.com/OJFord/ ... /httpbin.yml"
);
use httpbin::ip;

fn main() {
    let auth = httpbin::ServerAuth::new();

    match ip::get(auth) {
        Ok(response) => match response.body() {
            ip::get::OkBody::Status200(body)
                => println!("Your IP is {}", body.origin),
            _ => printn!("httpbin.org did something unexpected"),
        },
        Err(response)
            => println!("httpbin.org error: {}", response.body()),
    }
}
```

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  - 1/4 would actually use it
    - 2/4 would prefer a schema-less client
    - 1/4 would prefer an RPC framework

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- Force handling of errors when they do occur
- Boost developer productivity

Thank you!