Union Types in Flow & Reason

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May 17, 2018

Union types are Powerful!

Union Types: An Example

```
type A = 'A'
type B = 'B'
type AorB = A | B;

const whichBranch = (x: AorB): string => {
  switch (x.tag) {
    case 'A':
      return "In branch A";
    case 'B':
      return "In branch B";
    default:
      (x.tag: empty);
      throw new Error('impossible');
  }
}
```

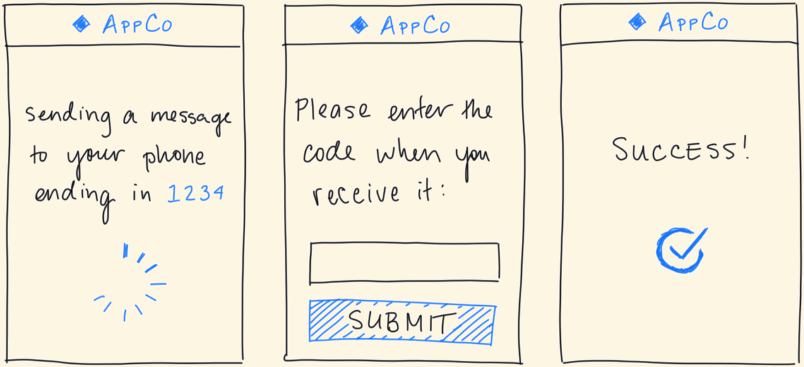
Union types in Flow have a cost :(

Outline

- Set up a problem that union types can solve
- Further motivate **why** we want union types
- Examine the cost of union types in Flow
- Show how Reason avoids this cost
- Bonus: compare other compile-to-JS languages

Union Types in a React Component

Consider a simple two-factor authentication modal:


AppCo
sending a message to your phone ending in 1234
AppCo
Please enter the code when you receive it:
SUBMIT
AppCo
SUCCESS!

We can model this with a union type

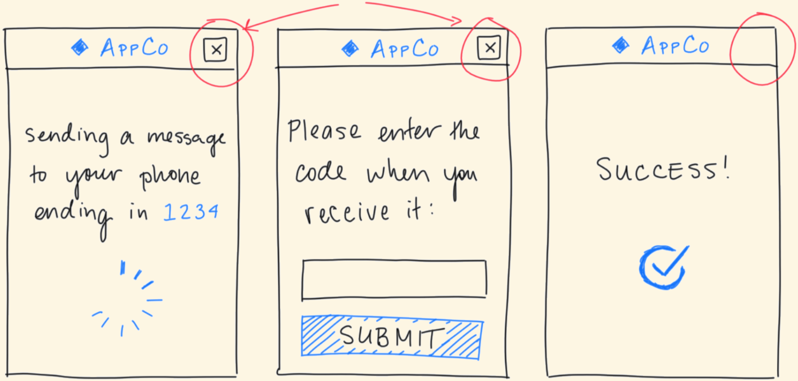
```
type Screen =
  | 'LoadingScreen'
  | 'CodeEntryScreen'
  | 'SuccessScreen';
```

Benefits to using a union type:

- Documentation in the types
- Developers (and our compiler) immediately know: “These are **all** the cases.”
- Flow can warn us when we’ve forgotten a case

Initial Feedback? Add a "cancel" button

After showing it to our team, someone suggests adding a cancel button:

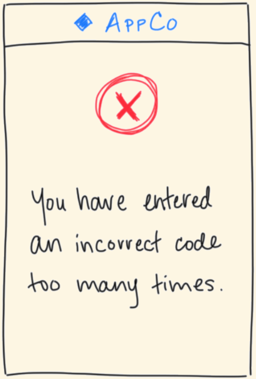

AppCo
×
sending a message to your phone ending in 1234
AppCo
×
Please enter the code when you receive it:
SUBMIT
AppCo
Success!

In particular: no need for a cancel button on the last screen!

`needsCancelButton`: Initial Implementation

```
const needsCancelButton = (screen: Screen): boolean => {
  // Recall: 'SuccessScreen' is final, so it doesn't
  // make sense to have a cancel button.
  return screen !== 'SuccessScreen';
};
```

Adding a `'FailureScreen'`



You have entered an incorrect code too many times.

Our Updated `Screen` Type

```
type Screen =
  | 'LoadingScreen'
  | 'CodeEntryScreen'
  | 'SuccessScreen'
  // New case to handle too many wrong attempts:
  | 'FailureScreen';
```

Oh no! A bug!

After changing the type, we update our code. But in particular, say we forget to update `needsCancelButton`:

```
const needsCancelButton = (screen: Screen): boolean => {
  return screen !== 'SuccessScreen';
};
```

When we save and run Flow… it passes! Flow couldn’t warn us that `needsCancelButton` doesn’t account for the case we added.

Thus: a silent bug! (There shouldn’t be a cancel button on `'FailureScreen'`, but there is.)

First reaction: just fix the bug.

```
const needsCancelButton = (screen: Screen): boolean => {
  return (
    screen !== 'SuccessScreen' ||
    screen !== 'FailureScreen'
  );
};
```

But we can do better! Let’s **prevent future bugs** from happening…

`switch`: Taking Advantage of Exhaustiveness

```
const needsCancelButton = (screen: Screen): boolean => {
  switch (screen) {
    case 'LoadingScreen':
      return true;
    case 'CodeEntryScreen':
      return true;
    case 'SuccessScreen':
      return false;
    default:
      // [flow]: Error: Cannot call `absurd` with
      // `screen` bound to `x` because string literal
      // `FailureScreen` is incompatible with empty
      return absurd(screen);
  }
}
```

Takeaway: Only use union types with `switch`!

Every time we use a union **without** a `switch` statement, Flow **can't tell us** when we're missing something.

Always[1] use `switch` statements with unions!

[1] Of course, use your best judgement. Sometimes you don't want to use a `switch`. But *know* that you're giving up static guarantees!

Correctness, but at what cost?

```
// ----- before: 62 bytes (minified) -----

const needsCancelButton = (screen) => {
  return screen !== 'SuccessScreen';
};
```

Correctness, but at what cost?

```
// ----- after: 240 bytes (minified) -----
const absurd = (x) => {
  throw new Error('This case is impossible.');
};
const needsCancelButton = (screen) => {
  switch (screen) {
    case 'LoadingScreen':
      return true;
    case 'CodeEntryScreen':
      return true;
    case 'SuccessScreen':
      return false;
    default:
      return absurd(screen);
  }
};
```

Correctness, at the cost of bundle size!

`needsCancelButton` is a bit of a pathological case:

- Short case bodies.
- Only one case is different.
- Long-ish string constants.

But still: I've **definitely** felt the impact in the wild!

Types and Optimizing Compilers

Types promise better compiled code.

Proponents of types argue:

“If we write code using **higher-level abstractions**, then compilers can do more optimizations for us.”

Flow is not a compiler

We’ve seen this **isn’t** a promise Flow gives us.

Flow isn’t a **compiler**, only a type checker.

By stripping the types, Babel / Webpack / Uglify lose access to making potential optimizations.

In particular: we threw away the exhaustiveness guarantee!

Enter: Reason

Reason (i.e., ReasonML) brings OCaml tools to the web.

OCaml offers:

- Mature optimizing compiler
- Wide ecosystem of packages
- **Great** type system

Reason adds:

- Tight JavaScript interop (via BuckleScript)
- Familiar syntax (looks like Flow!)

`needsCancelButton` in Reason

```
type screen =
  | LoadingScreen
  | CodeEntryScreen
  | SuccessScreen;

let needsCancelButton = (screen: screen): bool => {
  switch (screen) {
  | LoadingScreen => true;
  | CodeEntryScreen => true;
  | SuccessScreen => false;
  }
};
```

Reason looks pretty familiar!

Key differences compared to Flow:

- Custom datatype, instead of abusing strings
- Replaced `case` keyword with pipe in `switch`
- Exhaustiveness by default

The `|` instead of `case` is nice: we can copy / paste our type definition to kickstart our `switch` statement!

Reason’s Generated Code

```
// Generated by BUCKLESCRIPT VERSION 3.0.1
'use strict';

function needsCancelButton(status) {
  if (status !== 2) {
    return false;
  } else {
    return true;
  }
}
// ---------------------------------------
```

Entire `switch` statement optimized down to a single `if`!
`'SuccessScreen'` shortened to `2`!

Reason’s Generated Code + `uglify`

```
"use strict";
function needsCancelButton(n){
  return !(n>=2)
}
```

Uglify can shorten it even further: no `if` statement!

This is **even better** than our hand-written implementation.

Yet, we **didn’t sacrifice** safety or readability!

Safety AND Performance

Reason’s type system delivered on the promise of types in a way Flow couldn’t:

- We wrote high-level, expressive code.
- The type checker gave us strong guarantees about the correctness (exhaustiveness) of our code.
- The compiler translated that all to tiny, performant code.

Bonus: Comparing Other Languages

TypeScript

```
var Screen_; (function (Screen_) {
    Screen_[Screen_["LoadingScreen"] = 0] = "LoadingScreen";
    Screen_[Screen_["CodeEntryScreen"] = 1] = "CodeEntryScreen";
    Screen_[Screen_["SuccessScreen"] = 2] = "SuccessScreen";
})(Screen_ || (Screen_ = {}));
var impossible = function (x) {
    throw new Error('This case is impossible.');
};
var needsCancelButton = function (screen) {
    switch (screen) {
        case Screen_.LoadingScreen: return true;
        case Screen_.CodeEntryScreen: return true;
        case Screen_.SuccessScreen: return false;
        default: return impossible(screen);
    }
};
```

PureScript

```
"use strict";
var LoadingScreen = (function () {
    function LoadingScreen() {};
    LoadingScreen.value = new LoadingScreen();
    return LoadingScreen;
})();
var CodeEntryScreen = (function () {
    function CodeEntryScreen() {};
    CodeEntryScreen.value = new CodeEntryScreen();
    return CodeEntryScreen;
})();
var SuccessScreen = (function () {
    function SuccessScreen() {};
    SuccessScreen.value = new SuccessScreen();
    return SuccessScreen;
})();
var needsCancelButton = function (v) {
    if (v instanceof LoadingScreen) {
        return true;
    };
    if (v instanceof CodeEntryScreen) {
        return true;
    };
    if (v instanceof SuccessScreen) {
        return false;
    };
    throw new Error("Failed pattern match at Main line 10, column 1");
};
```

Elm

```
var _user$project$Main$needsCancelButton = function (page) {
  var _p0 = page;
  switch (_p0.ctor) {
    case 'LoadingScreen':
      return true;
    case 'CodeEntryScreen':
      return true;
    default:
      return false;
  }
};
var _user$project$Main$SuccessScreen = {ctor: 'SuccessScreen'};
var _user$project$Main$CodeEntryScreen = {ctor: 'CodeEntryScreen'};
var _user$project$Main$LoadingScreen = {ctor: 'LoadingScreen'};
```

Further Reading

- Case Exhaustiveness in Flow
- Union Types in Flow & Reason
- Tagged Unions in Flow
- Pattern Matching in Reason