Better TypeScript Types

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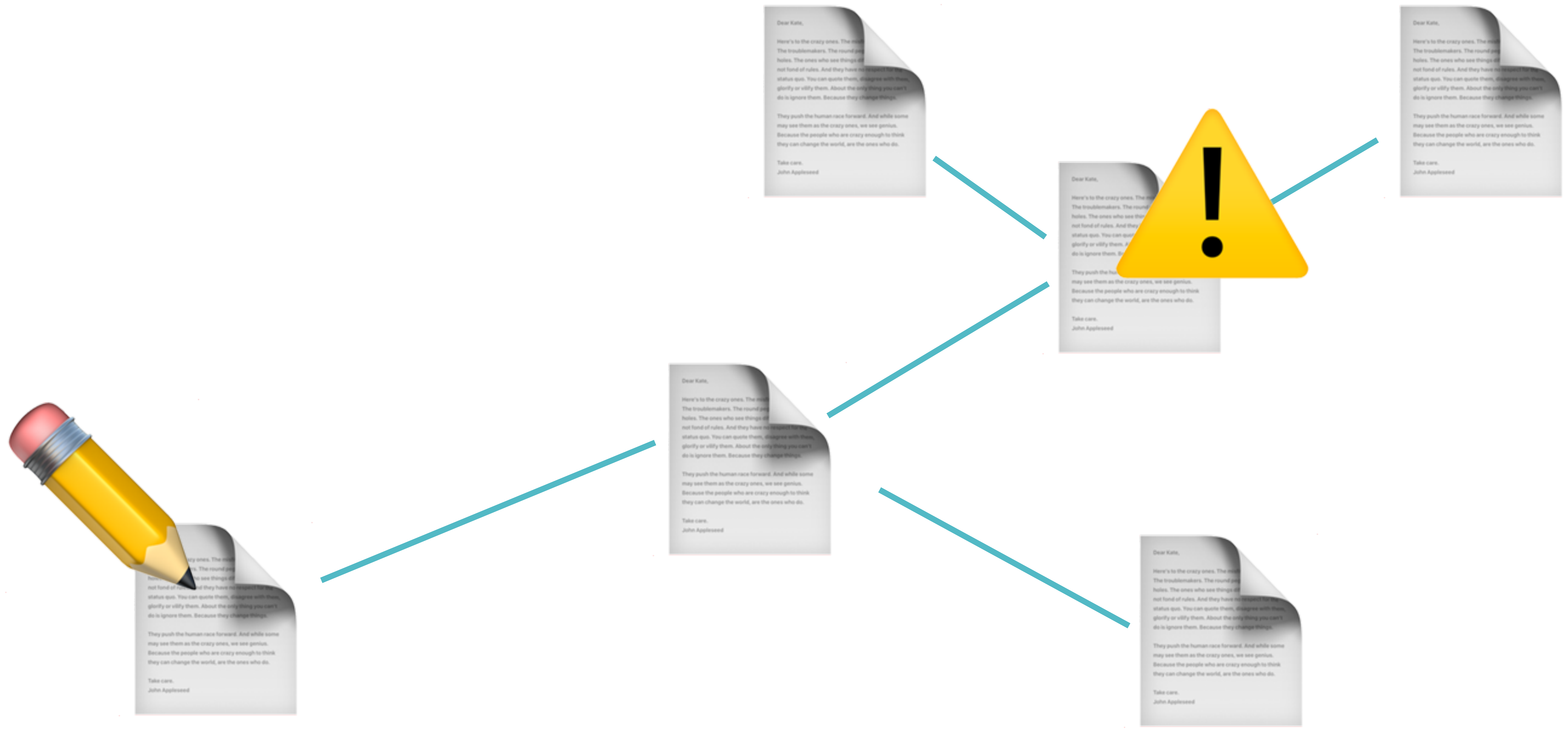
Audience Interaction Time

0) Why

Write down my assumptions in a way the computer understands, then have it tell me when I'm wrong.



1) Possibilities

1.1) Keep only what's needed

```
function icon(type: string): string {
  ...
}
```

```
// CSS class name for icon
function icon(type: string): string {
  return `icon icon-${type}`;
}
```

```
// CSS class name for icon
function icon(type: string): string {
  return `icon icon-${type}`;
}
```

```
type Icon = 'spinner' | 'save';

function icon(type: Icon): string {
  ...
}
```

```
type Icon = 'spinner' | 'save';

function icon(type: Icon): string {
  ...
}
```

string

string

```
""
```

string

```
""
        "spinner"
```

string

```
""
"spinner"
"Hello, world!"
```

string

```
""
"spinner"
"Hello, world!"
"不忍人之心"
```

string

""

"spinner"

"Hello, world!"

"ACT I
SCENE I. Athens. The palace of
THESEUS.

Enter THESEUS, HIPPOLYTA,
PHILOSTRATE, and Attendants

..."

"不忍人之心"

```
"spinner" | "save"
```

```
"spinner" | "save"
```

```
"spinner"
```

```
"spinner" | "save"
```

```
"spinner"
```

```
"save"
```

Possibilities:
lim n -> ∞...?

Possibilities:
2

1.2) Don't spread a choice across multiple values.

```
type Props = {
  success?: boolean,
  warning?: boolean,
  error?:   boolean,
  ...
};

function Notification(props: Props): {
  ...
}
```

```
<Notification
  error={true}
>
  This is bad.
</Notification>
```

```
Notification({
  error: true,
  children: [
    "This is bad.",
  ]
})
```

```
<Notification
  error={true}
>
  This is bad.
</Notification>
```

```
<Notification
  error={true}
>
  This is bad.
</Notification>
```

```
<Notification
  success={true}
>
  This is good.
</Notification>
```

```
type Props = {
  success?: boolean,
  warning?: boolean,
  error?:   boolean,
  ...
};

function Notification(props: Props): {
  ...
}
```

```
<Notification
  success={true}
  error={true}
>
  This is ... ???
</Notification>
```

```
<Notification
  success={true}
  error={true}
>
  This is ... ???
</Notification>
```

```
type Props = {
  success?: boolean,
  warning?: boolean,
  error?:   boolean,
  ...
};

function Notification(props: Props): {
  ...
}
```

```
type Props = {
  success?: boolean,
  warning?: boolean,
  error?:   boolean,
  ...
};

function Notification(props: Props): {
  ...
}
```

```
type Props = {
  type: 'success' | 'warning' | 'error',
  ...
};



function Notification(props: Props): {
  ...
}
```

```
<Notification
  type="success"
>
  This is good.
</Notification>
```

```
<Notification
  type="success"
>
  This is good.
</Notification>
```

Possibilities:

(true,true,true + true,true,false + true,false,false + ...)

8

Possibilities:
3

1.3) Things that change separately

```
type Props = {
  type: 'success' | 'warning' | 'error',
  dismissable: boolean,
};



function Notification(props: Props): {
  ...
}
```

```
type Props = {
  type: 'success' | 'warning' | 'error',
  dismissable: boolean,
};



function Notification(props: Props): {
  ...
}
```

1.4) Convenient types are tempting but can leave gaps.

```
type Props = {
  items: Array<Item>,
};



function Carousel(props: Props): {
  ...
}
```

```
<Carousel
  items=[...]
/>
```

```
<Carousel
  items=[]
/>
```

```
type Props = {
  items: Array<Item>,
};



function Carousel(props: Props): {
  ...
}
```

```
type Props = {
  itemsBefore: Array<Item>
  currentItem: Item,
  itemsAfter: Array<Item>,
};

function Carousel(props: Props): {
  ...
}
```

```
type Props = {
  itemsBefore: Array<Item>
  currentItem: Item,
  itemsAfter: Array<Item>,
};

function Carousel(props: Props): {
  ...
}
```

```
<Carousel
  itemsBefore=[]
  item=...
  itemsAfter=[]
/>
```

```
<Carousel
  itemsBefore=[]
  item=...
  itemsAfter=[]
/>
```

1.5) Combining Unions and values that change separately

```
function Example(props: Props): {
  const [isLoading, setLoading] =
    useState(false);
  const [isError, setError] =
    useState(false);
  const [data, setData] =
    useState<string | null>(null);

  ...
}
```

```
type State = {
  isLoading: boolean,
  isError: boolean,
  data: null | string,
}
```

```
type State =
  | { type: 'loading' }
  | { type: 'error' }
  | { type: 'success',
      data: null | string
    }
```

Possibilities:

(1 + 1 + (1 x 2))

Possibilities:
4

Sums and Products

Possibilities

A single possibility is a '1'

(eg. `true`, `5`, `"hi"`, `undefined`)

Unions are Sums (addition)

Union types represent a group of 'either-or' possibilities.

Total states: add all the possibilities together.

```
type Icon =
  | "spinner"
  | "save"
```

```
type Icon =
  | "spinner"    ← 1
  | "save"
```

```
type Icon =
  | "spinner"     ← 1
  | "save"        ← 1
```

```
type Icon =
  | "spinner"    ← 1
  | "save"       ← 1
```

Possible states for `Icon`

```
type Icon =
  | "spinner"    ← 1
  | "save"       ← 1
```

Possible states for `Icon`

= 1 + 1

```
type Icon =
  | "spinner"    ← 1
  | "save"       ← 1
```

Possible states for `Icon`

$= 1 + 1$

$= 2$

```
type boolean =
  | true          ← 1
  | false         ← 1
```

Possible states for `boolean`

$= 1 + 1$

$= 2$

```
type undefined =
  | undefined     ← 1
```

Possible states for `undefined`

= 1

```
type Icon = 'spinner' | 'save';

function icon(type: Icon): string {
  ...
}
```

Values that change independently are Products (multiplication)

Total states: multiply the groups of possibilities together.

```
type Props = {
  success?: boolean,
  warning?: boolean,
  error?:   boolean,
  ...
};

function Notification(props: Props): {
  ...
}
```

```
type Props = {
  success?: boolean,
  warning?: boolean,
  error?:   boolean,
  ...
};
```

```
type Props = {
  success?: boolean,    success: true,
  warning?: boolean,    warning: false,
  error?:   boolean,    error:   false,
  ...
};
```

```
type Props = {
  success?: boolean,    success: false,
  warning?: boolean,    warning: true,
  error?:   boolean,    error:   true,
  ...
};
```

```
type Props = {
  success?: boolean,    success: false,
  warning?: boolean,    warning: false,
  error?:   boolean,    error:   false,
  ...
};
```

```
type Props = {
  success?: boolean,
  warning?: boolean,
  error?:   boolean,
  ...
};
```

```
type Props = {
  success?: boolean,
  warning?: boolean,
  error?:   boolean,
  ...
};
```

← **true + false**

```
type Props = {
  success?: boolean,     ← 1 + 1
  warning?: boolean,
  error?:   boolean,
  ...
};
```

```
type Props = {
  success?: boolean,    ← 1 + 1
  warning?: boolean,    ← 1 + 1
  error?:   boolean,
  ...
};
```

```
type Props = {
  success?: boolean,    ← 1 + 1
  warning?: boolean,    ← 1 + 1
  error?:   boolean,    ← 1 + 1
  ...
};
```

```
type Props = {
  success?: boolean,    ← 1 + 1
  warning?: boolean,    ← 1 + 1
  error?:   boolean,    ← 1 + 1
  ...
};
```

Possible states for `Props`

```
type Props = {
  success?: boolean,    ← 1 + 1
  warning?: boolean,    ← 1 + 1
  error?:   boolean,    ← 1 + 1
  ...
};
```

Possible states for `Props`

$$= (1 + 1) \times (1 + 1) \times (1 + 1)$$

```
type Props = {
  success?: boolean,    ← 1 + 1
  warning?: boolean,    ← 1 + 1
  error?:   boolean,    ← 1 + 1
  ...
};
```

Possible states for `Props`

$= (1 + 1) \times (1 + 1) \times (1 + 1)$

$= 8$

2) Exhaustivity

```
type Icon = 'spinner' | 'save';

function icon(type: Icon): string {
  ...
}
```

```
type Icon = 'spinner' | 'save';

function icon(type: Icon): string {
  switch (type) {
    case 'spinner': ...
    case 'save': ...
  }
}
```

```
type Icon = 'spinner' | 'save' | 'ok';

function icon(type: Icon): string {
  switch (type) {
    case 'spinner': ...
    case 'save': ...
  }
}
```

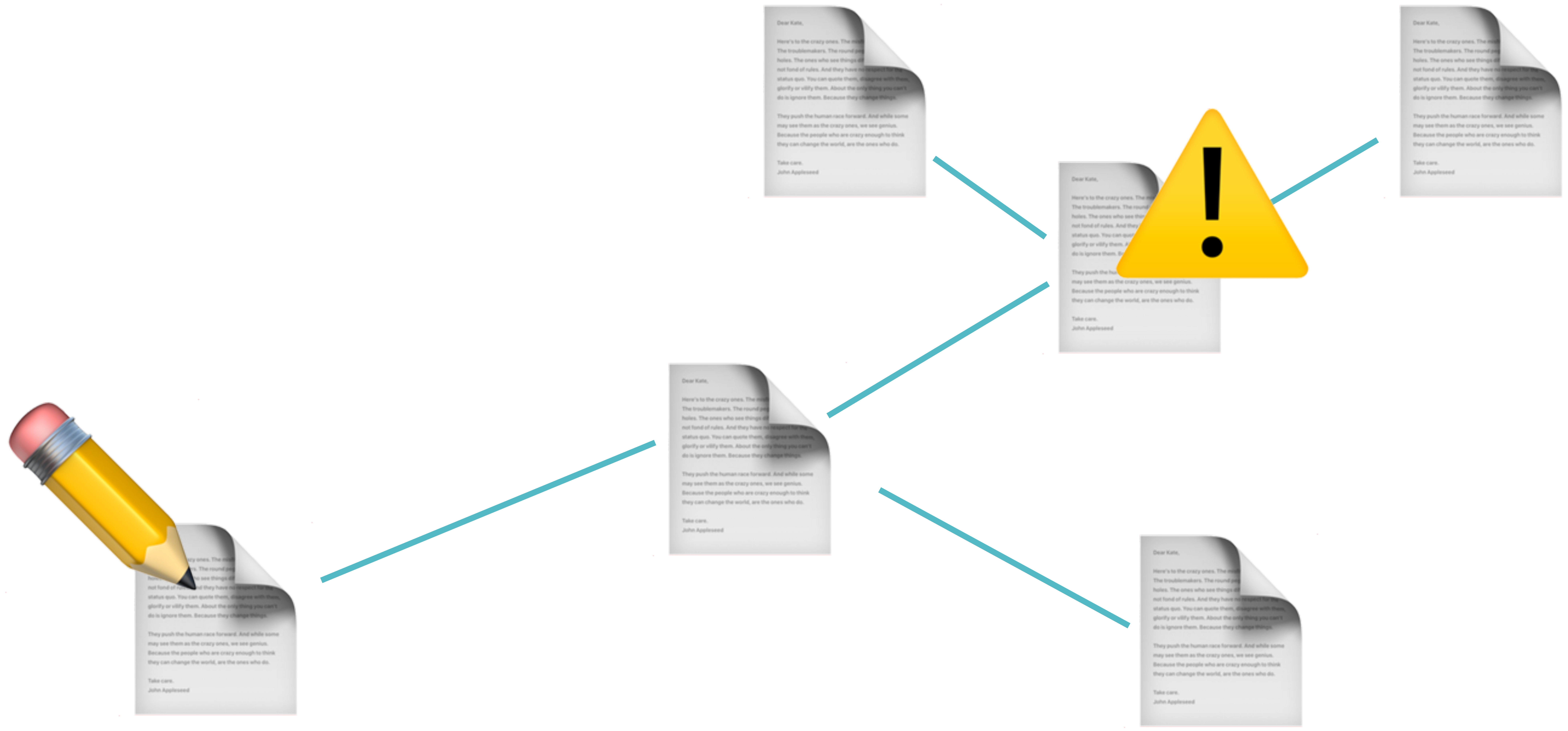
```
type Icon = 'spinner' | 'save' | 'ok';

function icon(type: Icon): string {
  switch (type) {
    case 'spinner': ...
    case 'save': ...
  }
}
```

```
type Icon = 'spinner' | 'save' | 'ok';

function icon(type: Icon): string {
  switch (type) {
    case 'spinner': ...
    case 'save': ...
  }
}
```

```
Function lacks ending
return statement and
return type does not
include 'undefined'.
```

```
type Icon = 'spinner' | 'save' | 'ok';

function icon(type: Icon): string {
  switch (type) {
    case 'spinner': ...
    case 'save': ...
    case 'ok': ...
  }
}
```

```
type Icon = 'spinner' | 'save' | 'ok';

function icon(type: Icon): string {
  switch (type) {
    case 'spinner': ...
    case 'save': ...
    case 'ok': ...
  }
}
```



```
type Example = boolean | string;


function example(x: Example): number {
  switch (typeof x) {
    case 'boolean':
      ...
    case 'string':
      ...
  }
}
```

```
type Example = boolean | string;


function example(x: Example): number {
  switch (typeof x) {
    case 'boolean':
      ...
    case 'string':
      ...
  }
}
```

```
type Example = boolean | string;


function example(x: Example): number {
  switch (typeof x) {
    case 'boolean':
      ...                        ← x is a boolean in here
    case 'string':
      ...
  }
}
```

```
type Example = boolean | string;


function example(x: Example): number {
  switch (typeof x) {
    case 'boolean':
      ...                    ← x is a boolean in here
    case 'string':
      ...                    ← x is a string in here
  }
}
```

```
type Example = boolean | string;


function example(x: Example): number {
  switch (typeof x) {     ← switch() satisfies
    case 'boolean':          TS's exhaustivity checker.
      ...                 ← x is a boolean in here
    case 'string':

      ...                 ← x is a string in here
  }
}
```

```
type Example = boolean | string;


function example(x: Example): number {
  switch (typeof x) {      ← switch() satisfies
    case 'boolean':          TS's exhaustivity checker.
      ...                  ← x is a boolean in here
    case 'string':
      ...                  ← x is a string in here
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  } else if (typeof x === 'string') {
    ...
  }
}
```

```typescript
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  } else if (typeof x === 'string') {
    ...
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  } else if (typeof x === 'string') {
    ...
  }
}
```

Function lacks ending return statement and return type does not include 'undefined'.

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  }
  switch (typeof x) {
    case 'string':
      ...
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  }
  switch (typeof x) {
    case 'string':
      ...
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...                        ← x is an array in here
  }
  switch (typeof x) {
    case 'string':
      ...
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  }
  switch (typeof x) {
    case 'string':
      ...
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  }
  switch (typeof x) {
    case 'string':
      ...                    ← x is a string in here.
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  }
  switch (typeof x) {      ← switch() satisfies
    case 'string':           TS's exhaustivity checker.
      ...                  ← x is a string in here.
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  }
  switch (typeof x) {
    case 'string':
      ...
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  }
  switch (typeof x) {
    case 'string':
      ...
  }
}
```

```
type Example = Array<string> | string;


function example(x: Example): number {
  if (Array.isArray(x)) {
    ...
  }
  switch (typeof x) {
    case 'string':
      ...
  }
}
```

```
class Foo { ... }; class Bar { ... };
type Example = Foo | Bar;

function example(x: Example): number {
  if (x instanceof Foo) {
    ...
  } else if (x instanceof Bar) {
    ...
  }

}
```

```
class Foo { ... }; class Bar { ... };
type Example = Foo | Bar;

function example(x: Example): number {
  if (x instanceof Foo) {        ← Can't use switch().
    ...
  } else if (x instanceof Bar) {
    ...
  }
}
```

```
class Foo { ... }; class Bar { ... };
type Example = Foo | Bar;

function example(x: Example): number {
  if (x instanceof Foo) {          ← Can't use switch().
    ...
  } else if (x instanceof Bar) { ←┐
    ...                            Can't use switch().
  }

}
```

```
class Foo { ... }; class Bar { ... };
type Example = Foo | Bar;

function example(x: Example): number {
  if (x instanceof Foo) {
    ...
  } else if (x instanceof Bar) {
    ...
  }

}
```

```
class Foo { ... }; class Bar { ... };
type Example = Foo | Bar;

function example(x: Example): number {
  if (x instanceof Foo) {
    ...
  } else if (x instanceof Bar) {
    ...
  }
}
```

Function lacks ending return statement and return type does not include 'undefined'.

```
class Foo { ... }; class Bar { ... };
type Example = Foo | Bar;

function example(x: Example): number {
  if (x instanceof Foo) {
    ...
  } else if (x instanceof Bar) {
    ...
  }
  return notExhaustive(x);
}
```

```
function notExhaustive(e: never): never {
  throw new Error(`Not exhaustive: ${e}`);
}
function example(x: Example): number {
  if (x instanceof Foo) {
    ...
  } else if (x instanceof Bar) {
    ...
  }
  return notExhaustive(x);
}
```

```
function notExhaustive(e: never): never {
  throw new Error(`Not exhaustive: ${e}`);
}
function example(x: Example): number {
  if (x instanceof Foo) {
    ...
  } else if (x instanceof Bar) {
    ...
  }
  return notExhaustive(x);
}
```

```
function notExhaustive(e: never): never {
  throw new Error(`Not exhaustive: ${e}`);
}
function example(x: Example): number {
  if (x instanceof Foo) {
    ...
  } else if (x instanceof Bar) {
    ...
  }
  return notExhaustive(x);
}
```

```
function notExhaustive(e: never): never {
  throw new Error(`Not exhaustive: ${e}`);
}
function example(x: Example): number {
  if (x instanceof Foo) {
    ...
  } else if (x instanceof Bar) {
    ...
  }
  return notExhaustive(x);
}
```

Edit:

A correction from the talk as given:

The `notExhaustive(e: never)` function will catch cases where you've not handled every type. This might happen while you're writing the function for the first time, for example, or adding a new type to `Example`.

My "*avoid* `switch()`*'s* `default)`, *and other fall-through catch–all returns*" advice still applies, but the `notExhaustive(e: never)` won't fail you here.

(My error was forgetting about the `e: never` parameter; this is critical.
Every time you refine an input (eg. `x`, our function parameter), such as checking its type with `typeof`, or using `Array.isArray()` or other Type Guards, TypeScript will remember that. By the time you get to the bottom of the function, if you've checked all the possibilities, you'll be left with a value of type `never`. This is given to `notExhaustive(e: never)`; if you still have some possible types to check, eg. if you've checked `string` but not `Array`, TypeScript will appropriately have a whinge and tell you that it's not yet a `never` and to go back and check a little harder.)

Type Guards & Exhaustivity

(It's a rabbit-hole; I'm still figuring this out myself.)

https://basarat.gitbooks.io/typescript/docs/types/typeGuard.html

https://www.typescriptlang.org/docs/handbook/advanced-types.html#exhaustiveness-checking

3) Intentionally-Different Types

If you mean something different, use a different type.

number

Row ID

Kilogram

Count

number

Length (cm)

Currency (AUD)

Currency (JP Yen)

```typescript
async function saveUser(
  id:    string,
  email: string
): Promise<User> {
  ...
}
// ...
await saveUser(id, "a@b.c");
```

```
async function saveUser(
  id:    string,
  email: string
): Promise<User> {
  ...
}
// ...
await saveUser(id, "a@b.c");
```

```
async function saveUser(
  id:    string,
  email: string
): Promise<User> {
  ...
}
// ...
await saveUser(id, "a@b.c");
```

```
async function saveUser(
  id:    string,
  email: string
): Promise<User> {
  ...
}
// ...
await saveUser("a@b.c", id);
```

```
async function saveUser(
  id:    string,
  email: string
): Promise<User> {
  ...
}
// ...
await saveUser(id, "a@b.c");
```

Method #1: Context

```
async function saveUser(
  id:    string,
  email: string
): Promise<User> {
  ...
}
// ...
await saveUser(id, "a@b.c");
```

```
async function saveUser({ id, email }:{
  id:     string,
  email: string
}): Promise<User> {
  ...
}
// ...
await saveUser({ id, email: "a@b.c"});
```

```
async function saveUser({ id, email }:{
  id:    string,
  email: string
}): Promise<User> {
  ...
}
// ...
await saveUser({ id, email: "a@b.c"});
```

```
type User = {
  id:    string,
  email: string,
};

async function saveUser(
  { id, email }: User
): Promise<User> {
  ...
}
```

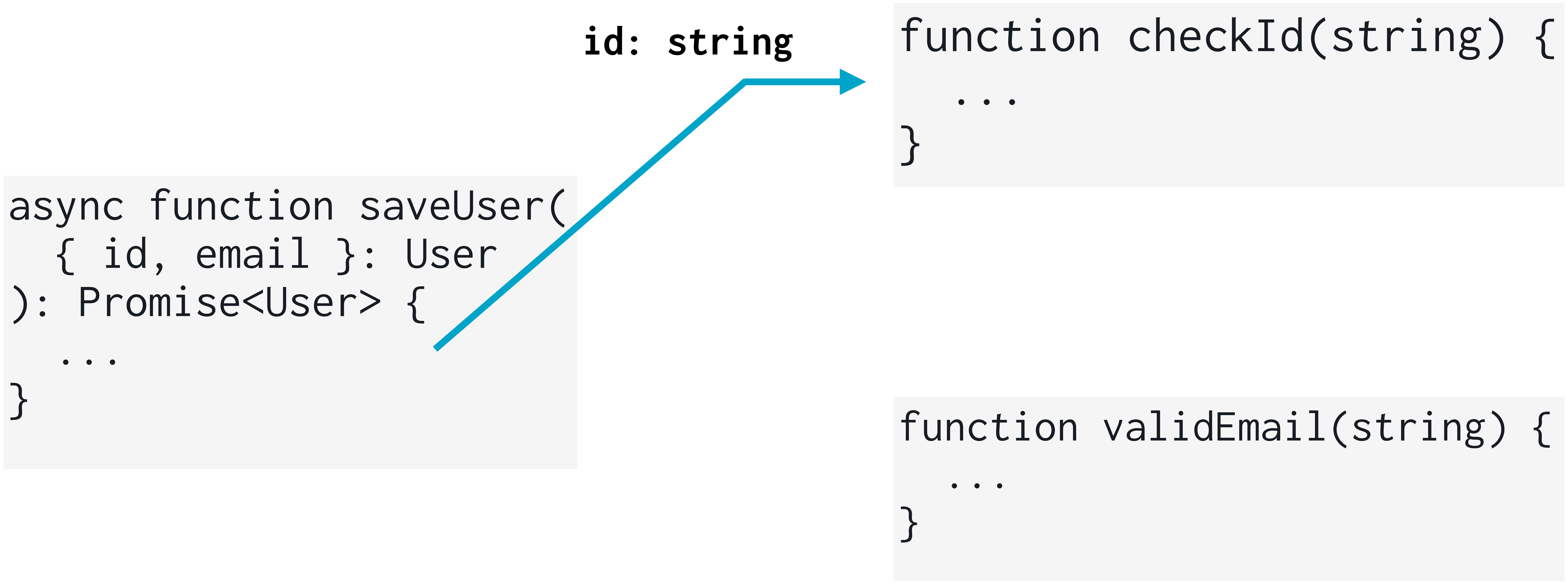
```
type User = {
  id:    string,
  email: string,
};

async function saveUser(
  { id, email }: User
): Promise<User> {
  ...
}
```

```
async function saveUser(
  { id, email }: User
): Promise<User> {
  ...
}
```

```
async function saveUser(
  { id, email }: User
): Promise<User> {
  ...
}
```

```
function checkId(string) {
  ...
}
```

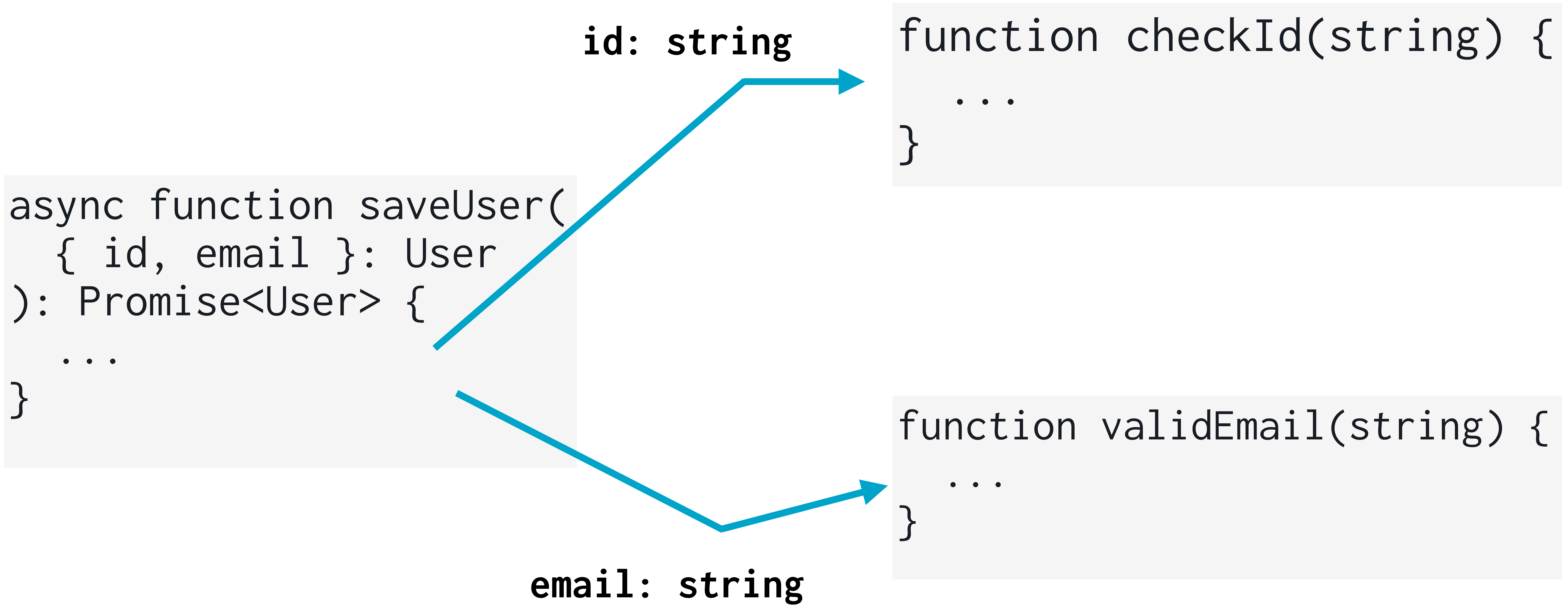
```
function validEmail(string) {
  ...
}
```



```
async function saveUser(
  { id, email }: User
): Promise<User> {
  ...
}
```

```
function checkId(string) {
  ...
}
```

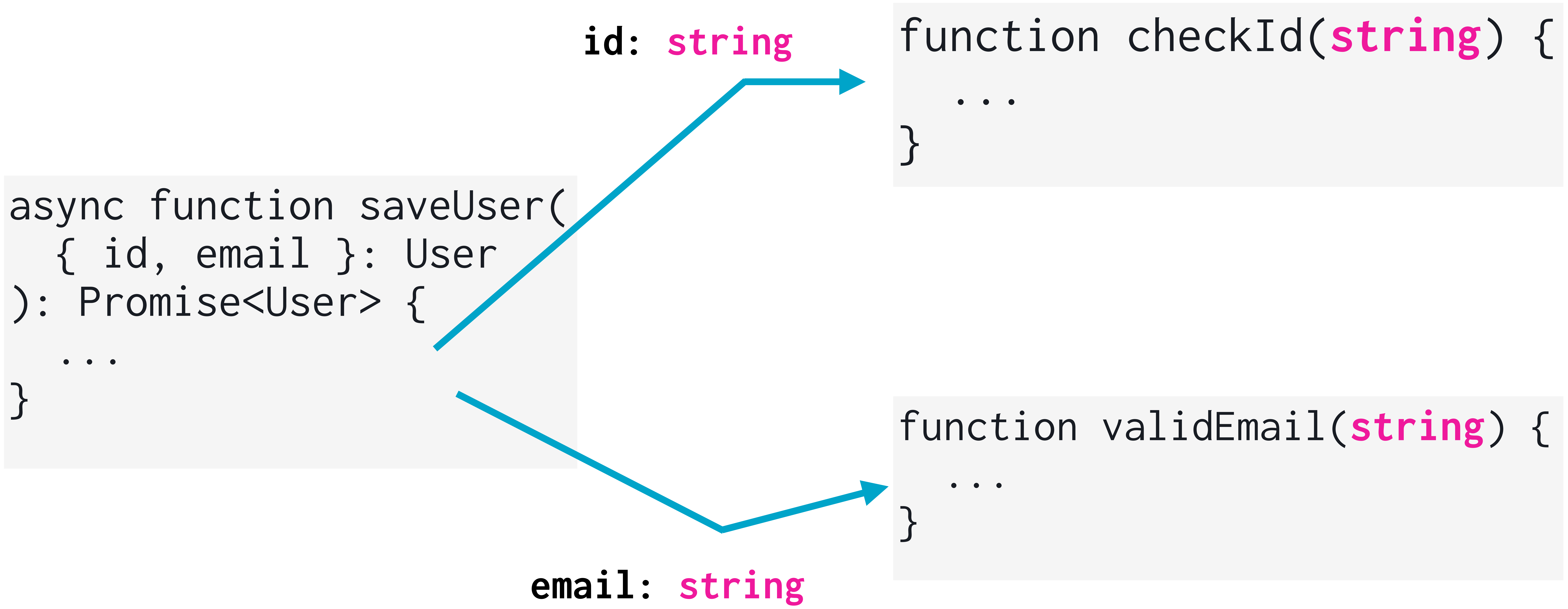
```
function validEmail(string) {
  ...
}
```



```
async function saveUser(
  { id, email }: User
): Promise<User> {
  ...
}
```

```
function checkId(string) {
  ...
}
```

```
function validEmail(string) {
  ...
}
```



```
async function saveUser(
  { id, email }: User
): Promise<User> {
  ...
}
```

```
function checkId(string) {
  ...
}
```

```
function validEmail(string) {
  ...
}
```

Method #2: Brands

(Opaque/nominal types)

```
type Brand<WrappedType, TypeName> =
  WrappedType & { __brand: TypeName };
```

```
type Brand<WrappedType, TypeName> =
  WrappedType & { __brand: TypeName };

type UserId = Brand<string, 'UserId'>;
type Brand<WrappedType, TypeName> =
  WrappedType & { __brand: TypeName };

type UserId = Brand<string, 'UserId'>;

const id = '1234-abcd' as UserId;
```

```
type Brand<WrappedType, TypeName> =
  WrappedType & { __brand: TypeName };

type UserId = Brand<string, 'UserId'>;

const id = '1234-abcd' as UserId;
const email = 'a@b.c';
```

```
type Brand<WrappedType, TypeName> =
  WrappedType & { __brand: TypeName };

type UserId = Brand<string, 'UserId'>;

const id = '1234-abcd' as UserId;
const email = 'a@b.c';

expectsUserId(id);
```

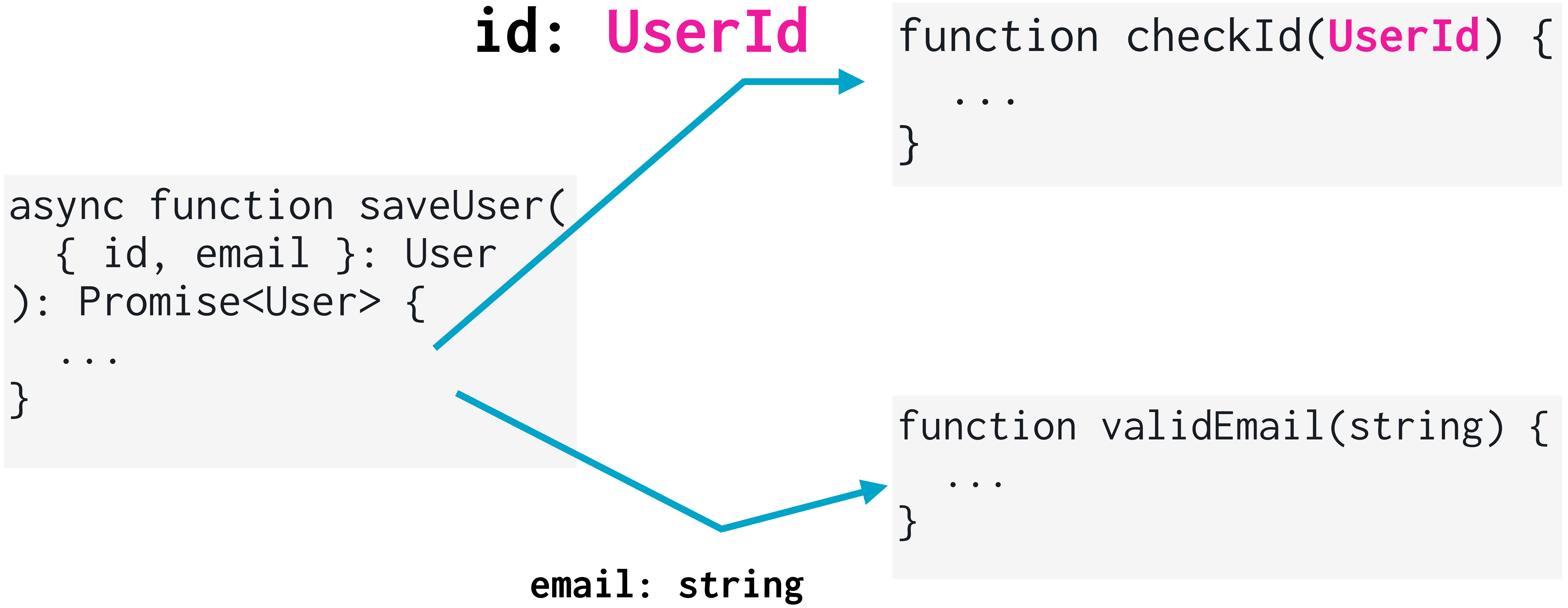
```
type Brand<WrappedType, TypeName> =
  WrappedType & { __brand: TypeName };

type UserId = Brand<string, 'UserId'>;

const id = '1234-abcd' as UserId;
const email = 'a@b.c';

expectsUserId(id);
expectsUserId(email);
```

```
type Brand<WrappedType, TypeName> =
  WrappedType & { __brand: TypeName };

type UserId = Brand<string, 'UserId'>;

const id = '1234-abcd' as UserId;
const email = 'a@b.c';

expectsUserId(id);     // ✅
expectsUserId(email);
```

```
type Brand<WrappedType, TypeName> =
  WrappedType & { __brand: TypeName };

type UserId = Brand<string, 'UserId'>;

const id = '1234-abcd' as UserId;
const email = 'a@b.c';

expectsUserId(id);    // ✅
expectsUserId(email); // ❌
```

```
stringToUserId(id: string): UserId

userIdToString(id: UserId): string
```

```
type User = {
  id:    UserId,
  email: string,
};

async function saveUser(
  { id, email }: User
): Promise<User> {
  ...
}
```



```
async function saveUser(
  { id, email }: User
): Promise<User> {
  ...
}
```

```
function checkId(UserId) {
  ...
}
```

```
function validEmail(string) {
  ...
}
```

4) Proving things to the type-checker

unknown => known

(implicitly: ... or throw an error)

```
(Array<Thing>) => NonEmptyArray<Thing>
```

```
function messageFromApi(
  raw: unknown
): { message: string } {
  if (typeof raw == 'object' && raw != ...) {
    return ...;
  }
}
```

```
import * as t from 'io-ts';

const User = t.type({
  id: t.string,
  email: t.string,
});

// Validation succeeded
User.decode(JSON.parse('{"id":1,"email":"g@z.com"}'));
  // => Right({ id: 1, name: "g@z.com" })

// Validation failed
User.decode(JSON.parse('{"email":"g@z.com"}'));
  // => Left([...])
```

5) Lightning Round of Odd Tips

```
--strict
```

Avoid numeric

`enum`

```
enum MyEnum {
  a = 1,
  b = 2,
}
function fun(en: MyEnum) {
  // ...
}

fun(666); // no error
```

https://twitter.com/GiulioCanti/status/1105873882882412545

Edit:

(String enums are
fortunately unaffected by this;
thanks, @nhardy96!)

readonly & ReadOnly<...>

https://www.typescriptlang.org/docs/handbook/utility-types.html

```
type User = {...};

// NewUser has everything except
// the 'id' field from User:
type NewUser =
  Exclude<User, 'id'>;
```

https://www.typescriptlang.org/docs/handbook/utility-types.html

`type` **vs** `interface`

https://medium.com/@martin_hotell/interface-vs-type-alias-in-typescript-2-7-2a8f1777af4c

interface

type

interface

type

interface

type

`any`

vs

`mixed / unknown`

vs

type variables (generics)

Bringing it all back.

- Shrink the possibilities for your input and output to as closely match what's going on in your head as you can muster.

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- Use exhaustivity to give yourself a to-do list when you change code.
- Use different types when you mean different things.
- 'Prove' things to the type checker so that it can do work for you.
- don't use numeric enums, please

Better TypeScript Types

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- https://michalzalecki.com/nominal-typing-in-typescript/
- https://www.typescriptlang.org/docs/handbook/utility-types.html
- https://dev.to/busypeoples/notes-on-typescript-pick-exclude-and-higher-order-components-40cp
- https://medium.com/@martin_hotell/interface-vs-type-alias-in-typescript-2-7-2a8f1777af4c
- https://mariusschulz.com/blog/typescript-3-0-the-unknown-type
- https://gcanti.github.io/io-ts/
- https://basarat.gitbooks.io/typescript/