Functional Programming *for* Fun & Profit*

Or: How I Learned to Stop Worrying and Love Shipping Haskell Code

Daniel Gąsienica
March 17, 2017

*after accomplishing step 2: ???

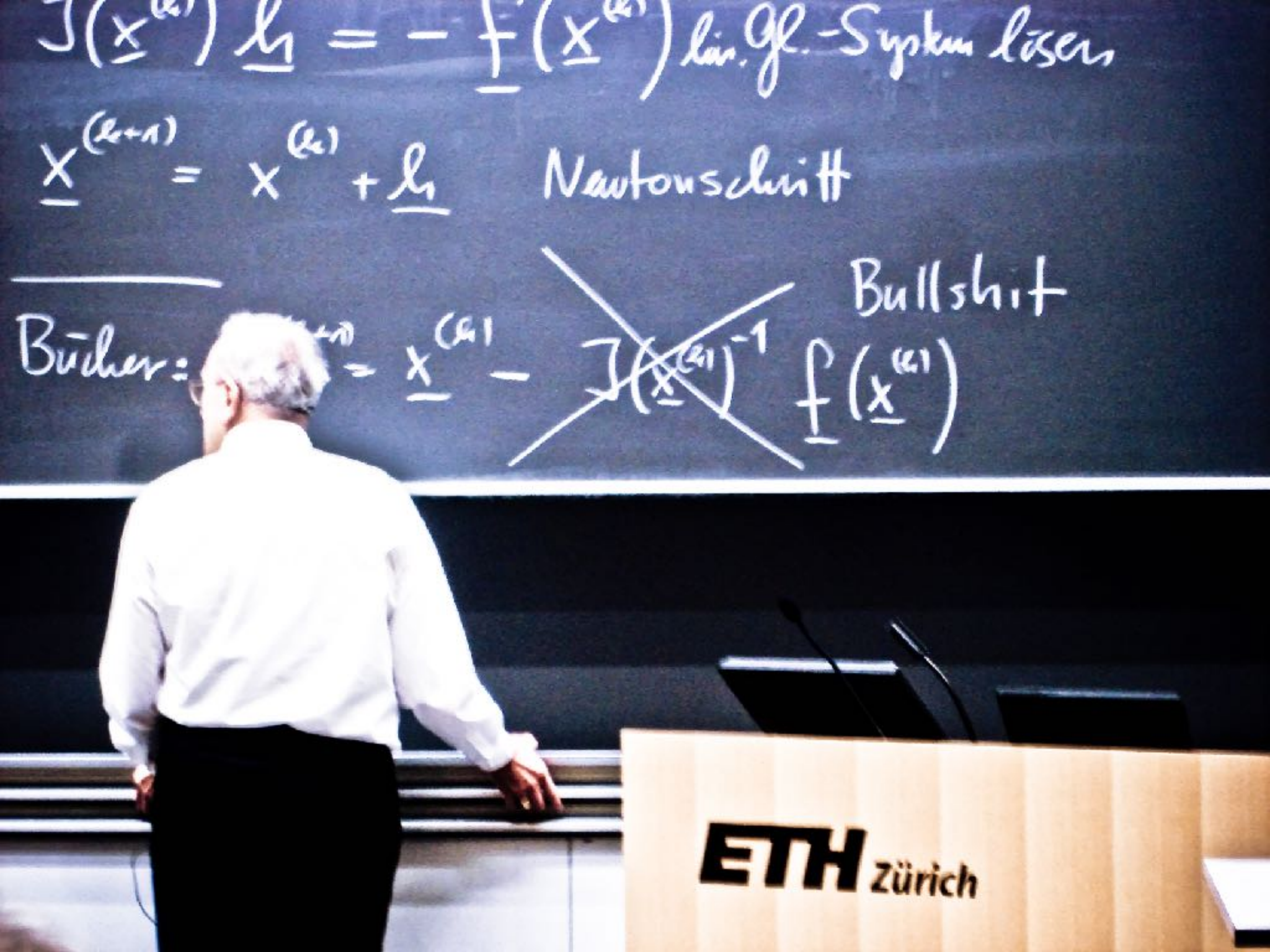
Background
Amuse-Bouches
Food for Thought*

*Opinions

What this talk *is* about

What this talk *is not* about

Background



$J(\underline{x}^{(k)})\,\underline{h} = -\underline{f}(\underline{x}^{(k)})$ lin. Gl.-System lösen

$\underline{x}^{(k+1)} = x^{(k)} + \underline{h}$ Newtonschritt

Bücher: $\underline{x}^{(k+1)} = \underline{x}^{(k)} - \cancel{J(\underline{x}^{(k)})^{-1}}\,\underline{f}(\underline{x}^{(k)})$ Bullshit

Thanksgiving 2015

Photo: https://commons.wikimedia.org/wiki/User:Braniff747SP zoomhub

http://zoomhub.net?url=http://www.rhysy.net/Timeline/LargeTimeline.png

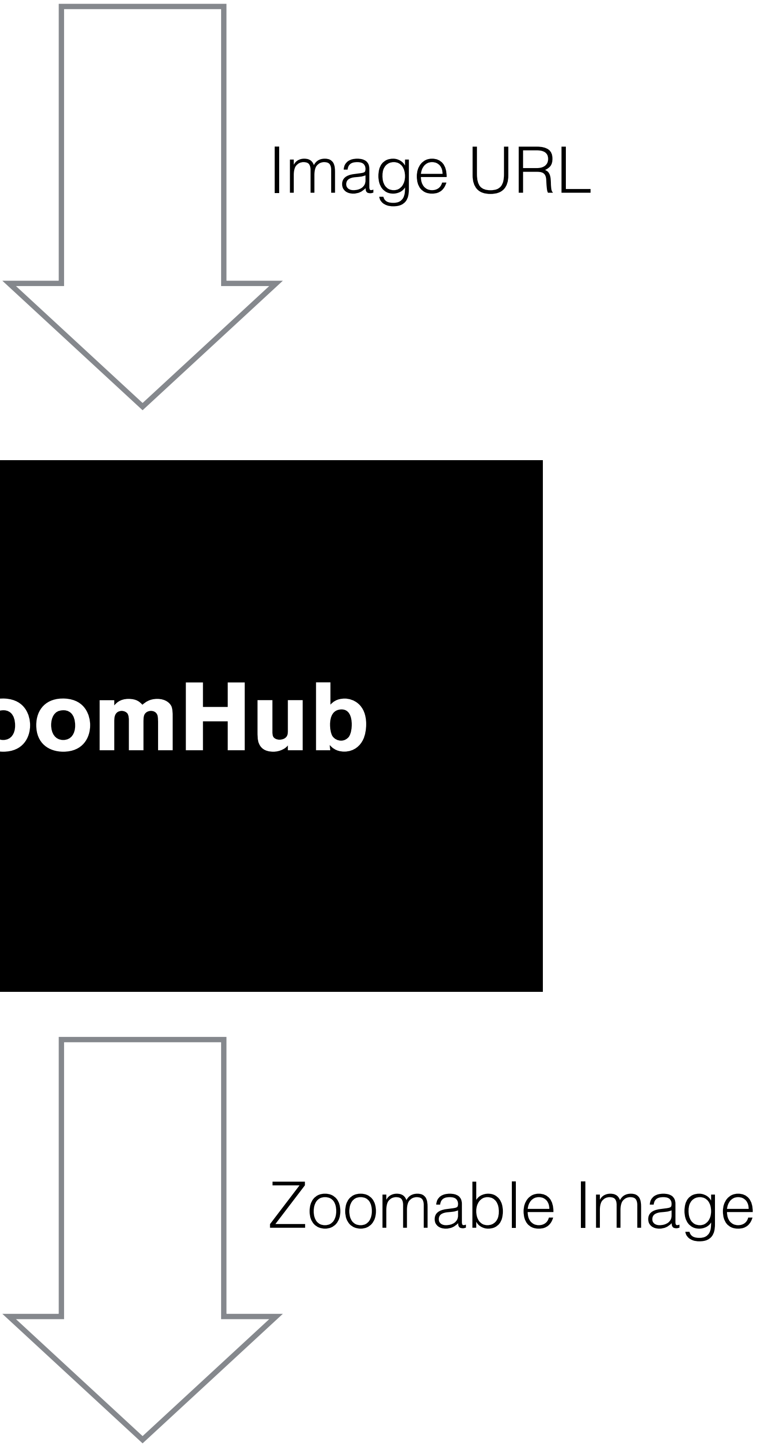


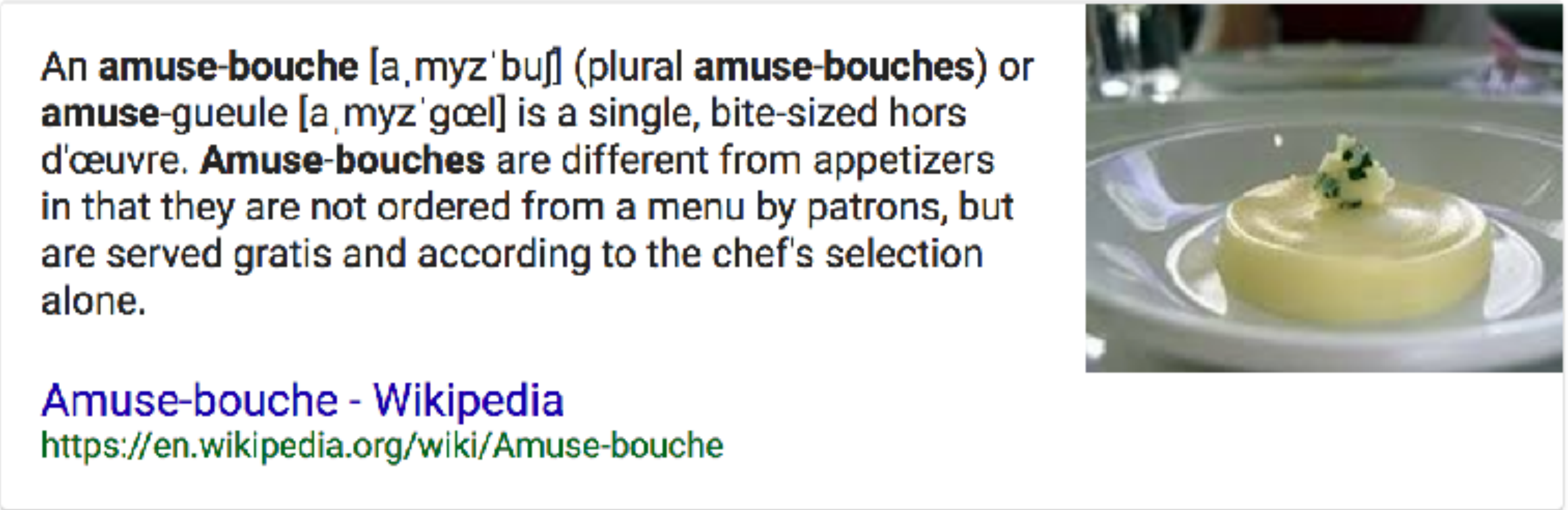
Image URL

ZoomHub

Zoomable Image

http://zoomhub.net/K4J1

Amuse-Bouches

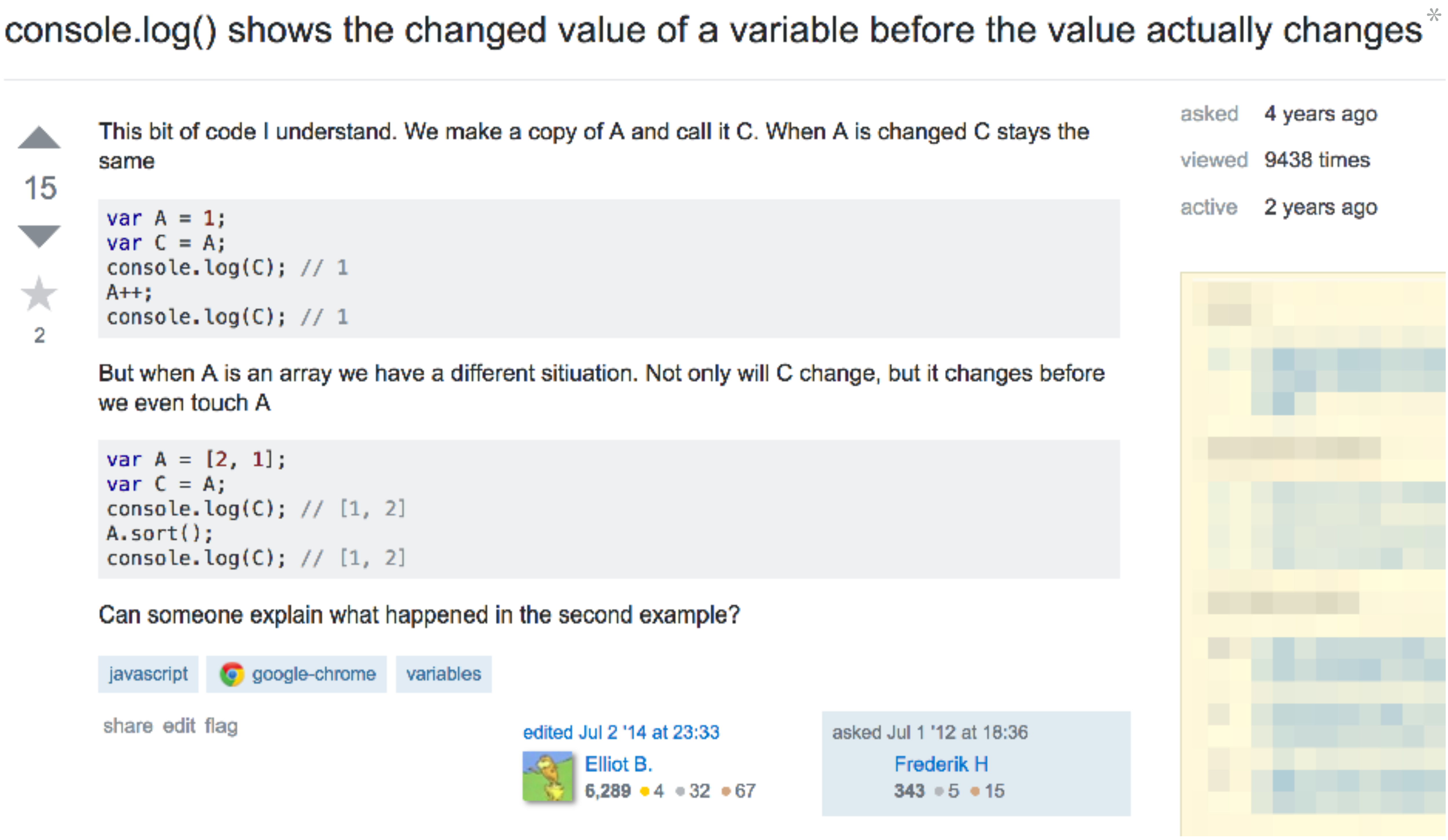


An **amuse-bouche** [aˌmyzˈbuʃ] (plural **amuse-bouches**) or **amuse**-gueule [aˌmyzˈɡœl] is a single, bite-sized hors d'œuvre. **Amuse-bouches** are different from appetizers in that they are not ordered from a menu by patrons, but are served gratis and according to the chef's selection alone.

Amuse-bouche - Wikipedia
https://en.wikipedia.org/wiki/Amuse-bouche

Immutability
&
The Value of Values

The Pain



console.log() shows the changed value of a variable before the value actually changes*

asked	4 years ago
viewed	9438 times
active	2 years ago

This bit of code I understand. We make a copy of A and call it C. When A is changed C stays the same

```
var A = 1;
var C = A;
console.log(C); // 1
A++;
console.log(C); // 1
```

But when A is an array we have a different sitiuation. Not only will C change, but it changes before we even touch A

```
var A = [2, 1];
var C = A;
console.log(C); // [1, 2]
A.sort();
console.log(C); // [1, 2]
```

Can someone explain what happened in the second example?

edited Jul 2 '14 at 23:33
Elliot B.
6,289 ●4 ●32 ●67

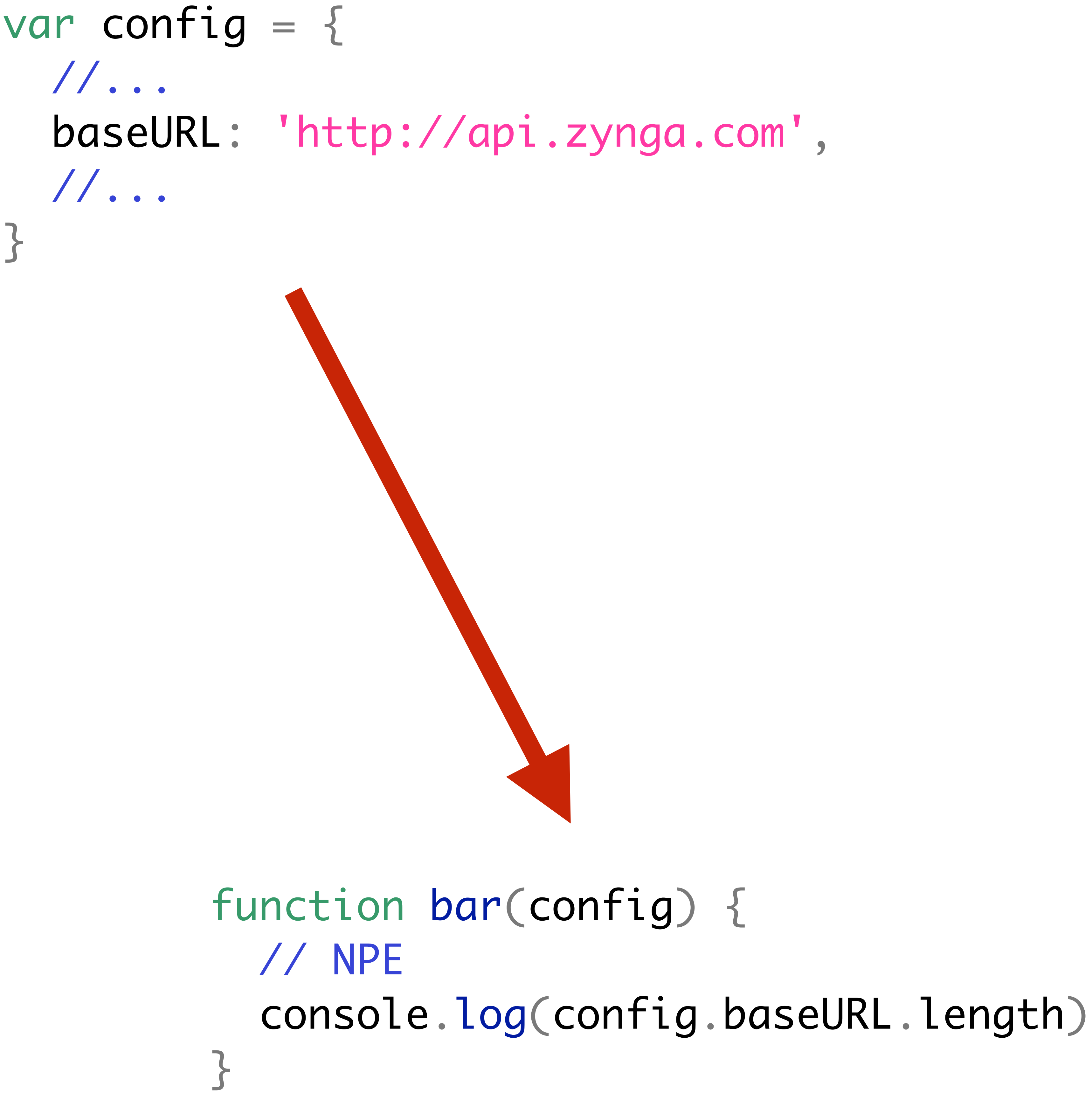
asked Jul 1 '12 at 18:36
Frederik H
343 ●5 ●15

* Fixed in recent versions of WebKit/Chrome

The Bugs

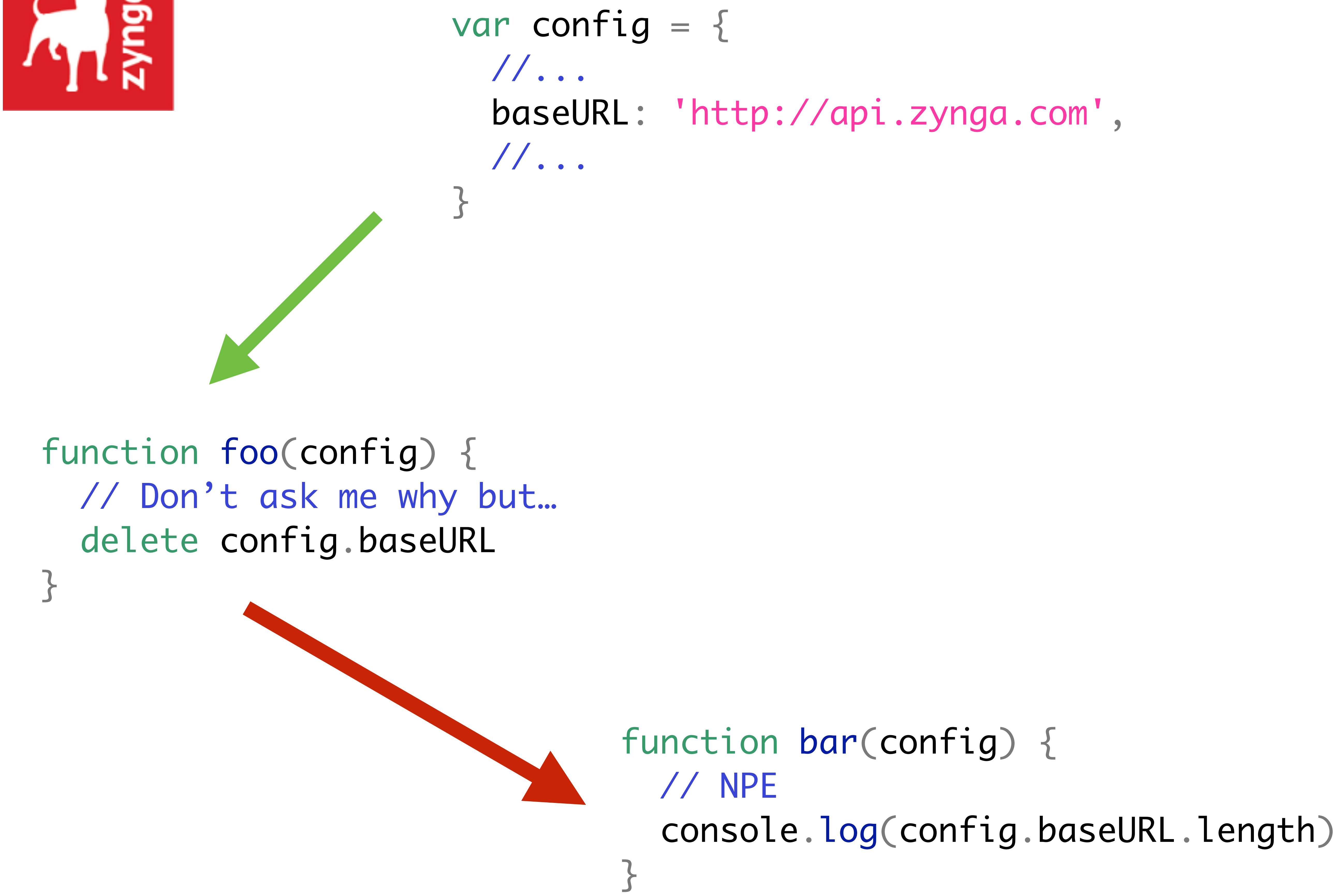
```
var config = {
  //...
  baseURL: 'http://api.zynga.com',
  //...
}
```

```
function bar(config) {
  console.log(config.baseURL.length)
}
```



```
var config = {
  //...
  baseURL: 'http://api.zynga.com',
  //...
}
```

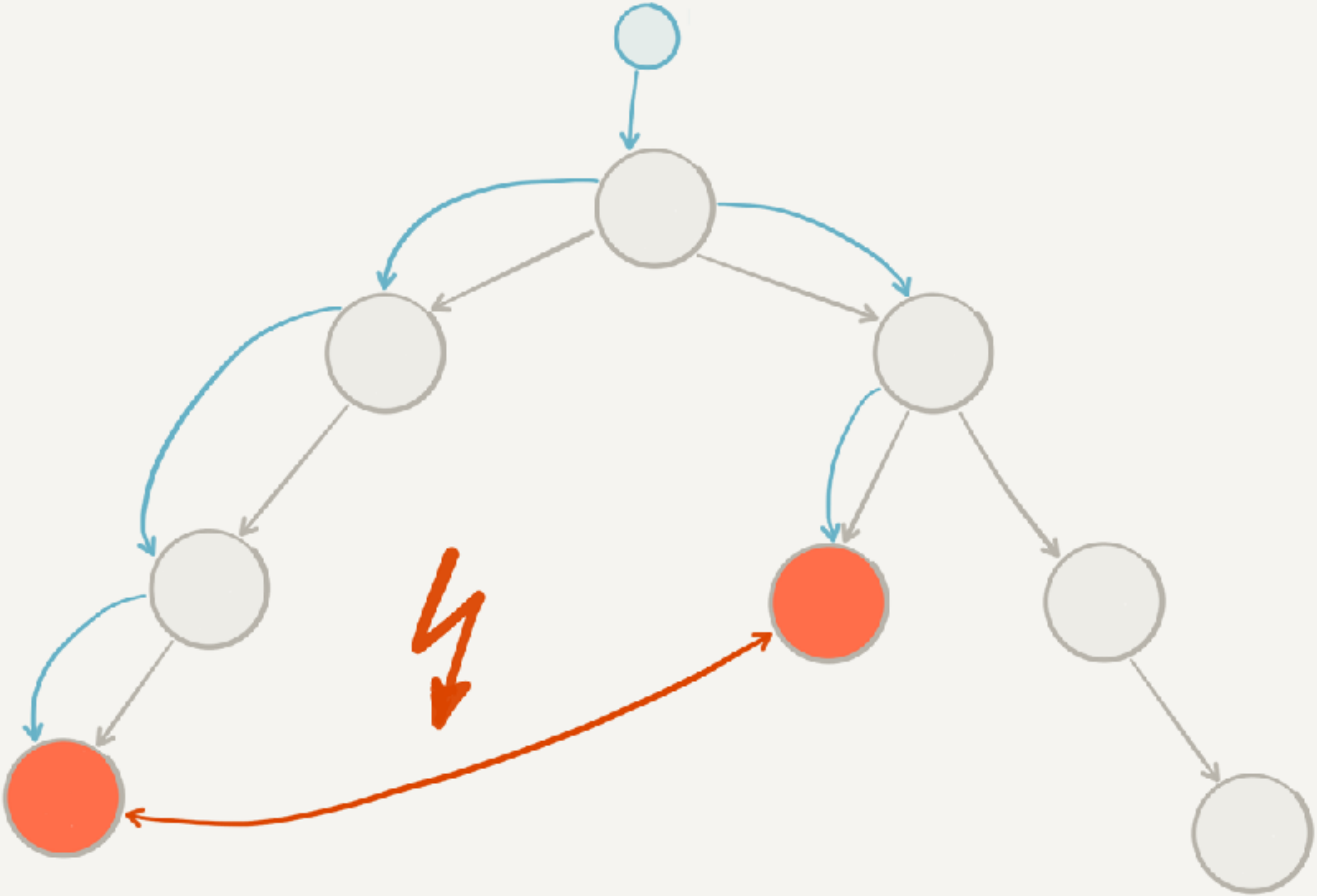
```
function bar(config) {
  // NPE
  console.log(config.baseURL.length)
}
```



```
var config = {
  //...
  baseURL: 'http://api.zynga.com',
  //...
}
```

```
function foo(config) {
  // Don’t ask me why but…
  delete config.baseURL
}
```

```
function bar(config) {
  // NPE
  console.log(config.baseURL.length)
}
```



The Confusion

```
> 1 === 1
true

> true === true
true

> "hello" === "hello"
true
```

```
> 1 === 1
true

> true === true
true

> "hello" === "hello"
true

> [] === []
false

> [1, 2] === [1, 2]
false

> {} === {}
false

> {"a": "b"} === {"a": "b"}
false
```

JS

```
> 1 === 1
true

> true === true
true

> "hello" === "hello"
true

> [] === []
false

> [1, 2] === [1, 2]
false

> {} === {}
false

> {"a": "b"} === {"a": "b"}
false
```

```
> 1 == 1
True

> True == True
True

> "hello" == "hello"
True

> [] == []
True

> [1, 2] == [1, 2]
True

> Map.fromList [] == Map.fromList []
True

> Map.fromList [("a", "b")] == Map.fromList [("a", "b")]
True
```

```
> let a = [3, 1, 2]

> let b = a.sort()

> b
[1, 2, 3]
```

```
> let a = [3, 1, 2]

> let b = a.sort()

> b
[1, 2, 3]

> a
[1, 2, 3]
```

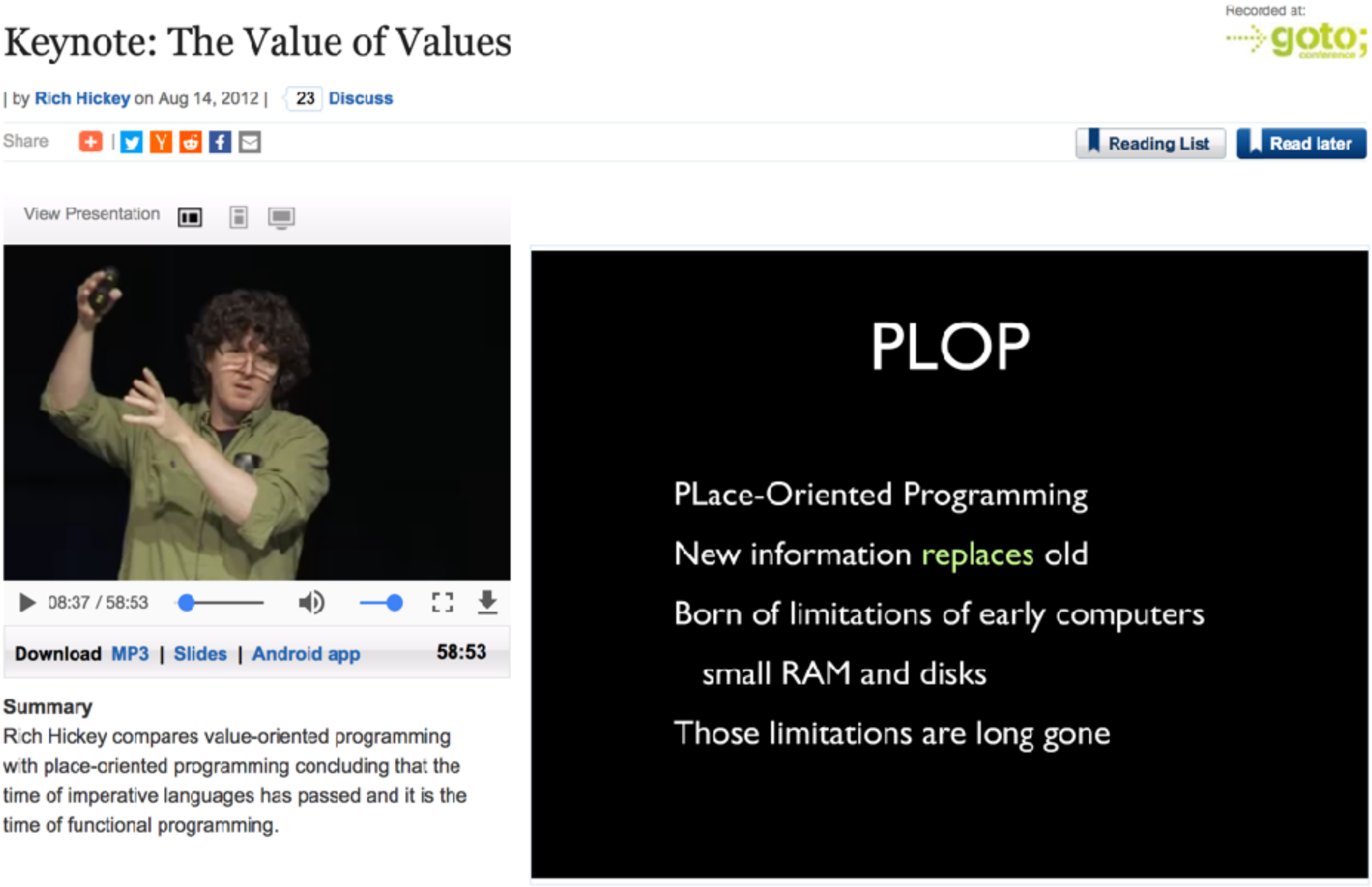
```
> let a = [3, 1, 2]

> let b = a.sort()

> b
[1, 2, 3]

> a
[1, 2, 3]
```

```
> let a = [3, 1, 2]

> let b = sort a

> b
[1, 2, 3]

> a
[3, 1, 2]
```

- space = function
-             application
- i.e. JavaScript: sort(a)

Conclusion

Abandon distinction between values and references and treat everything as immutable values.



Recorded at: goto; conference

Keynote: The Value of Values

| by Rich Hickey on Aug 14, 2012 | 23 Discuss

Download MP3 | Slides | Android app 58:53

Summary

Rich Hickey compares value-oriented programming with place-oriented programming concluding that the time of imperative languages has passed and it is the time of functional programming.

PLOP

PLace-Oriented Programming

New information replaces old

Born of limitations of early computers

small RAM and disks

Those limitations are long gone

https://www.infoq.com/presentations/Value-Values

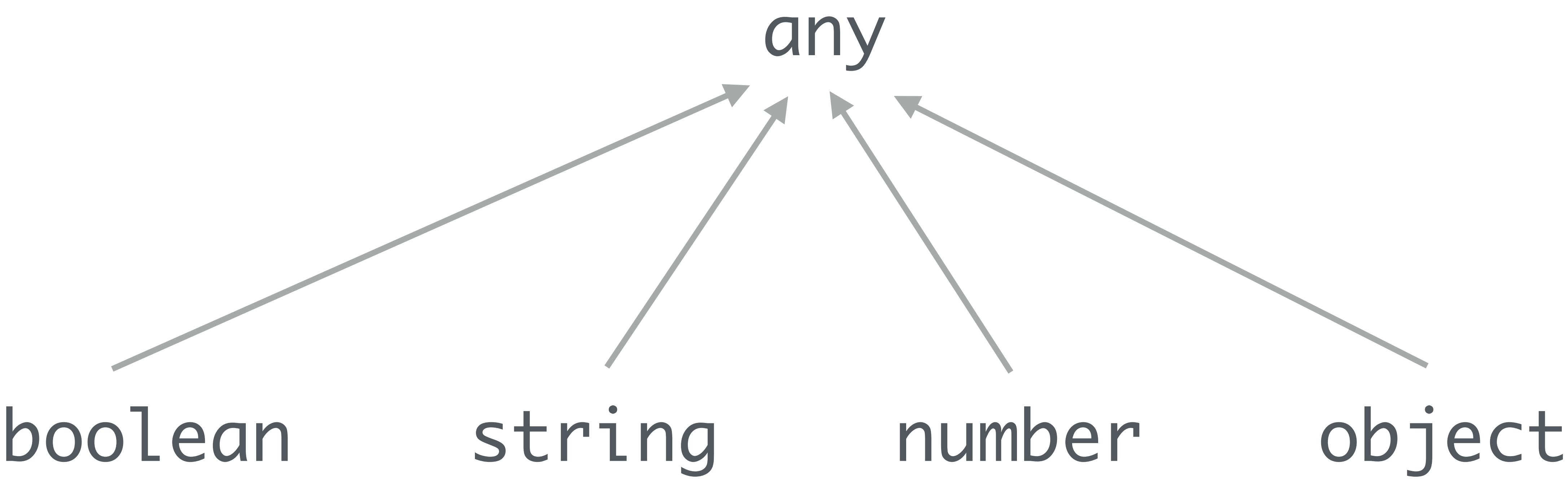
null

The Billion-Dollar Mistake

> “I call it my billion-dollar mistake.
> It was the invention of
> the null reference in 1965.”
>
> — C. A. R. Hoare

`boolean`   `string`   `number`   `object` any

boolean string number object



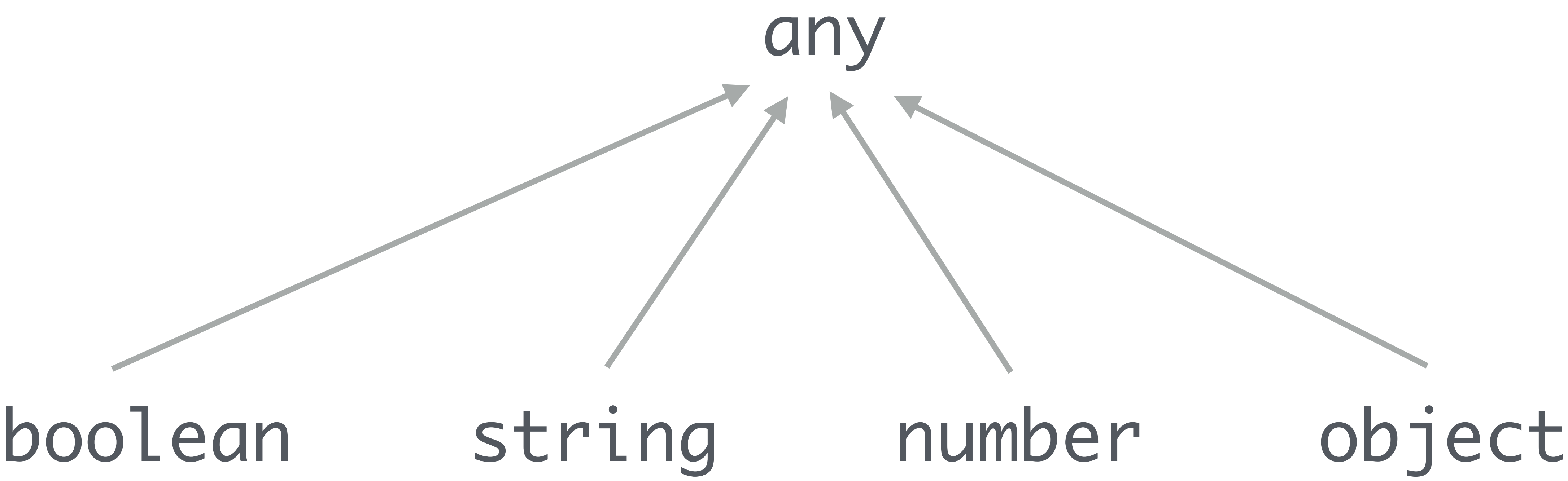
any

boolean

string

number

object



any

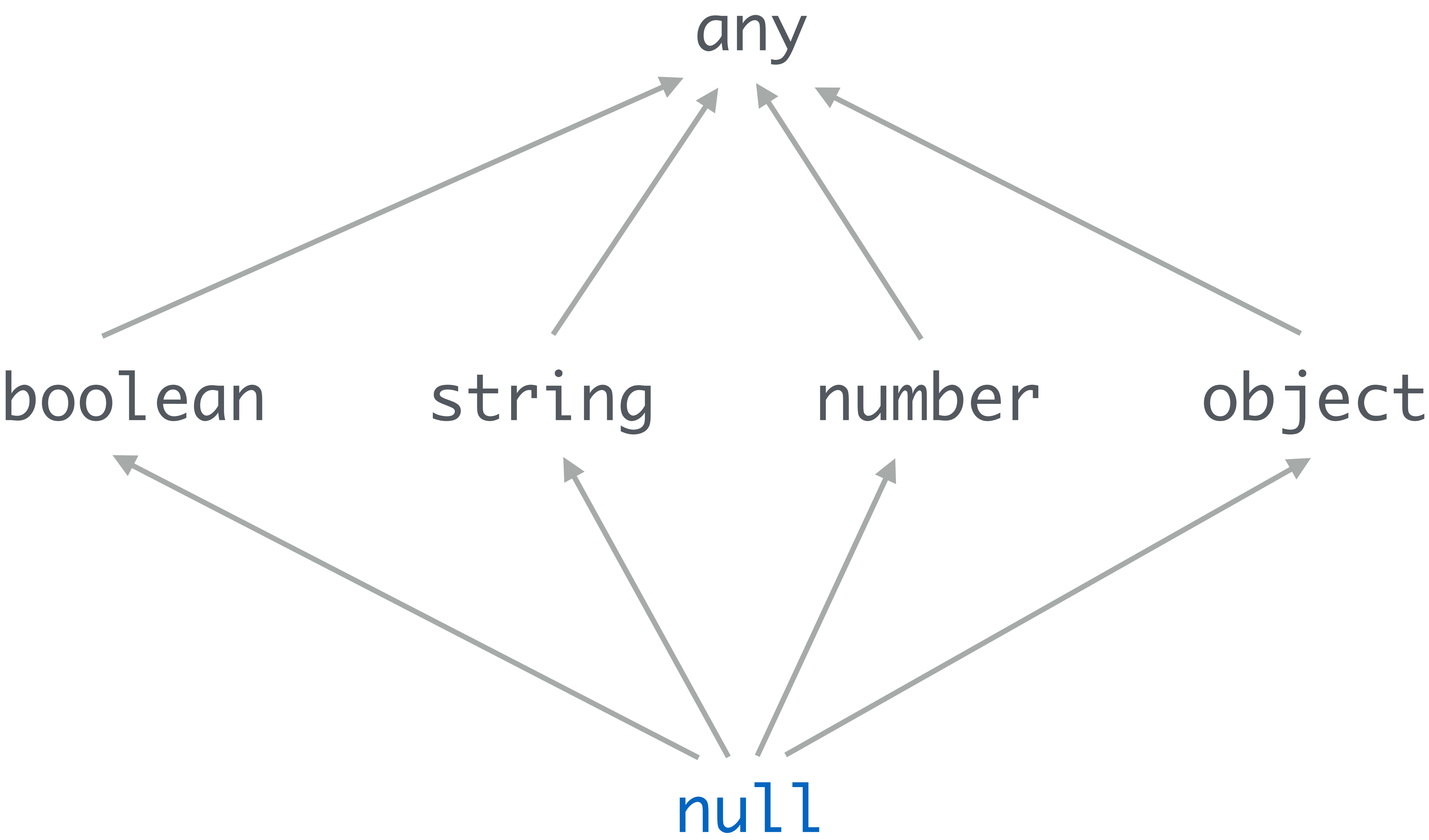
boolean

string

number

object

null



any

boolean

string

number

object

null

```
let names = ["Aseem", "Matt"]
let isCool = x => x.length <= 4
let name = names.find(isCool)
console.log(name.toUpperCase())
// > MATT
```

```
let names = ["Aseem", "Matt"]
let isCool = x => x.length <= 4
let name = names.find(isCool)
console.log(name.toUpperCase())
// > MATT
```

```
let names = ["Aseem"]
let isCool = x => x.length <= 4
let name = names.find(isCool)
console.log(name.toUpperCase())

// console.log(name.toUpperCase())
//                  ^
//
// TypeError: Cannot read property
// 'toUpperCase' of undefined
```

```
let names = ["Aseem", "Matt"]
let isCool = x => x.length <= 4
let name = names.find(isCool)
console.log(name.toUpperCase())
// > MATT
```

```
let names = ["Aseem"]
let isCool = x => x.length <= 4
let name = names.find(isCool)
console.log(name.toUpperCase())

// console.log(name.toUpperCase())
//                 ^
//
// TypeError: Cannot read property
// 'toUpperCase' of undefined
```

```
main = do
  let names = ["Aseem", "Matt"]
      isCool x = length x <= 4
      name = find isCool names
  print (toUpperCase name)

-- null.hs:5:22:
--  Coudn't match expected type ‘String’
--              with actual type ‘Maybe String’
--  In the first argument of ‘toUpperCase’,
--    namely ‘name’
--  In the first argument of ‘print’,
--    namely ‘(toUpperCase name)’
```

```
Array<A>.find(
  predicate: (value: A) => boolean
): A | null
```

```
find :: (a -> Bool) -> [a] -> Maybe a
```

```haskell
data Maybe a = Just a | Nothing
data Maybe a = Just a | Nothing
```

```haskell
foo :: Maybe Int
foo = Just 5
```

or

```haskell
foo = Nothing
```

```haskell
bar :: Maybe String
bar = Just "Hello"
```

or

```haskell
bar = Nothing
```

```
let names = ["Aseem"]
let isCool = x => x.length <= 4
let name = names.find(isCool)
console.log(name ?
  name.toUpperCase() : "nuddin"
)
// nuddin
```

```javascript
let names = ["Aseem"]
let isCool = x => x.length <= 4
let name = names.find(isCool)
console.log(name ?
  name.toUpperCase() : "nuddin"
)
// nuddin
```

```haskell
main = do
  let names = ["Aseem"]
      isCool x = length x <= 4
      name = find isCool names
  print (case name of
      Just s  -> toUpperCase s
      Nothing -> "nuddin"
    )
-- nuddin
```

Conclusion

Unhandled nulls can cause unexpected runtime errors.

Explicitly model the presence and absence of values and enforce handling of all cases.

Types

First-Class Compile-Time Type Safety

```haskell
data User = User
  { userId :: UserId
  , userEmail :: Email
  } deriving Show

newtype Email  = Email String deriving Show
newtype UserId = UserId String deriving Show

createUser :: UserId -> Email -> User
createUser userId userEmail = User { userId = userId, userEmail = userEmail }

-- Main
main = do
  let email = Email "daniel@fiftythree.com"
      userId = UserId "3490"
  print (createUser email userId)

{-
  types-user.hs:16:21:
    Couldn't match expected type ‘UserId’ with actual type ‘Email’
    In the first argument of ‘createUser’, namely ‘email’
    In the first argument of ‘print’, namely
      ‘(createUser email userId)’

  types-user.hs:16:27:
    Couldn't match expected type ‘Email’ with actual type ‘UserId’
    In the second argument of ‘createUser’, namely ‘userId’
    In the first argument of ‘print’, namely
      ‘(createUser email userId)’
-}
```

```
class User {
  private userId: string
  private userEmail: string

  constructor(userId: string, userEmail: string) {
    this.userId = userId
    this.userEmail = userEmail
  }
}

// Main
let email = 'daniel@fiftythree.com'
let userId = '3490'

console.log(new User(email, userId))
// User { userId: 'daniel@fiftythree.com', userEmail: '3490' }
```

```haskell
data User = User
  { userId :: UserId
  , userEmail :: Email
  } deriving Show
```

```typescript
class User {
  private userId: string
  private userEmail: string

  constructor(userId: string
              userEmail: string) {
    this.userId = userId
    this.userEmail = userEmail
  }
}
```

```typescript
// `deriving Show` is explicit generation
// of `Object.prototype.toString()`
```

```haskell
createUser :: UserId -> Email -> User
createUser userId userEmail = User
  { userId = userId
  , userEmail = userEmail
  }
```

```typescript
// function createUser(
//   userId: UserId,
//   userEmail: Email
// ): User
```

```typescript
class User {
  private userId: string
  private userEmail: string

  constructor(userId: string,
              userEmail: string) {
    this.userId = userId
    this.userEmail = userEmail
  }
}
```

```
-- Main
main = do
  let email = Email "daniel@fiftythree.com"
      userId = UserId "3490"
  print (createUser email userId)

{-
  types-user.hs:16:21:
    Couldn't match expected type ‘UserId’
      with actual type ‘Email’
    In the first argument of ‘createUser’,
      namely ‘email’
    In the first argument of ‘print’,
      namely ‘(createUser email userId)’

  types-user.hs:16:27:
    Couldn't match expected type ‘Email’
      with actual type ‘UserId’
    In the second argument of ‘createUser’,
      namely ‘userId’
    In the first argument of ‘print’,
      namely ‘(createUser email userId)’
-}
```

```
// Main
let email = 'daniel@fiftythree.com'
let userId = '3490'

console.log(new User(email, userId))
// User { userId: 'daniel@fiftythree.com',
//        userEmail: '3490' }
```

(Awkward) ‘Solution’

```typescript
class User {
  private userId: UserId
  private userEmail: Email

  constructor(userId: UserId, userEmail: Email) {
    this.userId = userId
    this.userEmail = userEmail
  }
}

type Email = string & {_emailBrand: any}
type UserId = string & {_userIdBrand: any}

// Main
let email = 'daniel@fiftythree.com' as Email
let userId = '3490' as UserId

console.log(new User(email, userId))
// Argument of type 'Email' is not assignable to parameter of type 'UserId'.
//   Type 'Email' is not assignable to type '{ _userIdBrand: any; }'.
//     Property '_userIdBrand' is missing in type 'Email'.
```

```haskell
newtype Email  = Email String deriving Show
newtype UserId = UserId String deriving Show

-- Main
main = do
  let email = Email "daniel@fiftythree.com"
      userId = UserId "3490"
  print (createUser email userId)
```

```haskell
newtype Email  = Email String deriving Show
newtype UserId = UserId String deriving Show

-- Main
main = do
  let email = Email "daniel@fiftythree.com"
      userId = UserId "3490"
  print (createUser email userId)
```

```typescript
type Email = string & {_emailBrand: any}
type UserId = string & {_userIdBrand: any}


// Main
let email = 'daniel@fiftythree.com' as Email
let userId = '3490' as UserId
console.log(new User(email, userId))
```

Language
Feature

```haskell
newtype Email  = Email String deriving Show
newtype UserId = UserId String deriving Show

-- Main
main = do
  let email = Email "daniel@fiftythree.com"
      userId = UserId "3490"
  print (createUser email userId)
```

```typescript
type Email = string & {_emailBrand: any}
type UserId = string & {_userIdBrand: any}


// Main
let email = 'daniel@fiftythree.com' as Email
let userId = '3490' as UserId
console.log(new User(email, userId))
```

Language Feature

```haskell
newtype Email  = Email String deriving Show
newtype UserId = UserId String deriving Show

-- Main
main = do
  let email = Email "daniel@fiftythree.com"
      userId = UserId "3490"
  print (createUser email userId)
```

Hack

```typescript
type Email = string & {_emailBrand: any}
type UserId = string & {_userIdBrand: any}


// Main
let email = 'daniel@fiftythree.com' as Email
let userId = '3490' as UserId
console.log(new User(email, userId))
```

‘Built-in’ Types

```
data Bool = True | False

// function and(a: boolean, b: boolean): boolean
and :: Bool -> Bool -> Bool
and True True = True
and _    _    = False

// function or(a: boolean, b: boolean): boolean
or :: Bool -> Bool -> Bool
or False False = False
or _     _     = True
```

```
data Bool = True | False
```

```
(&&) :: Bool -> Bool -> Bool
(&&) True True = True
(&&) _    _    = False
```

```
// Define: (&&)
// Use: True && False
```

```
(||) :: Bool -> Bool -> Bool
(||) False False = False
(||) _     _     = True
```

Security

“Make sure we *never* store plaintext passwords in our database.”

```haskell
newtype PlainTextPassword = PlainTextPassword String deriving Show
newtype HashedPassword = HashedPassword String deriving Show

getPassword :: IO PlainTextPassword
getPassword = do
  s <- getLine
  return (PlainTextPassword s)

hashPassword :: PlainTextPassword -> HashedPassword
hashPassword (PlainTextPassword s) = HashedPassword ((reverse s) ++ "$SALT$")

storePassword :: HashedPassword -> IO ()
storePassword (HashedPassword s) = putStrLn s

-- Main
main = do
  putStrLn "Enter password please:"
  p <- getPassword

  putStrLn "\nStored the following hashed password:"
  storePassword p

-- types-security.hs:21:17:
--     Couldn't match expected type ‘HashedPassword’
--                 with actual type ‘PlainTextPassword’
--     In the first argument of ‘storePassword’, namely ‘p’
--     In a stmt of a 'do' block: storePassword p
```

```haskell
newtype PlainTextPassword = PlainTextPassword String deriving Show
newtype HashedPassword = HashedPassword String deriving Show

getPassword :: IO PlainTextPassword
getPassword = do
  s <- getLine
  return (PlainTextPassword s)

hashPassword :: PlainTextPassword -> HashedPassword
hashPassword (PlainTextPassword s) = HashedPassword ((reverse s) ++ "$SALT$")

storePassword :: HashedPassword -> IO ()
storePassword (HashedPassword s) = putStrLn s

-- Main
main = do
  putStrLn "Enter password please:"
  p <- getPassword

  putStrLn "\nStored the following hashed password:"
  storePassword (hashPassword p) -- before: `storePassword p`

-- Enter password please:
-- passw0rd
--
-- Stored the following hashed password:
-- dr0wssap$SALT$
```

Conclusion

Types can help prevent many errors at compile-time.
They are a versatile and powerful tool to model your domain.

Abstraction & Type Classes

map

```
console.log([1, 2, 3].map(x => x * 3))
// [3, 6, 9]
// Array<A>.map<B>(fn: (value: A) => B): Array<B>
console.log([1, 2, 3].map(x => x * 3))
// [3, 6, 9]
```

```haskell
main = do
  -- map :: (a -> b) -> [a] -> [b]
  print (map (\x -> x * 3) [1, 2, 3])
  -- [3, 6, 9]
```

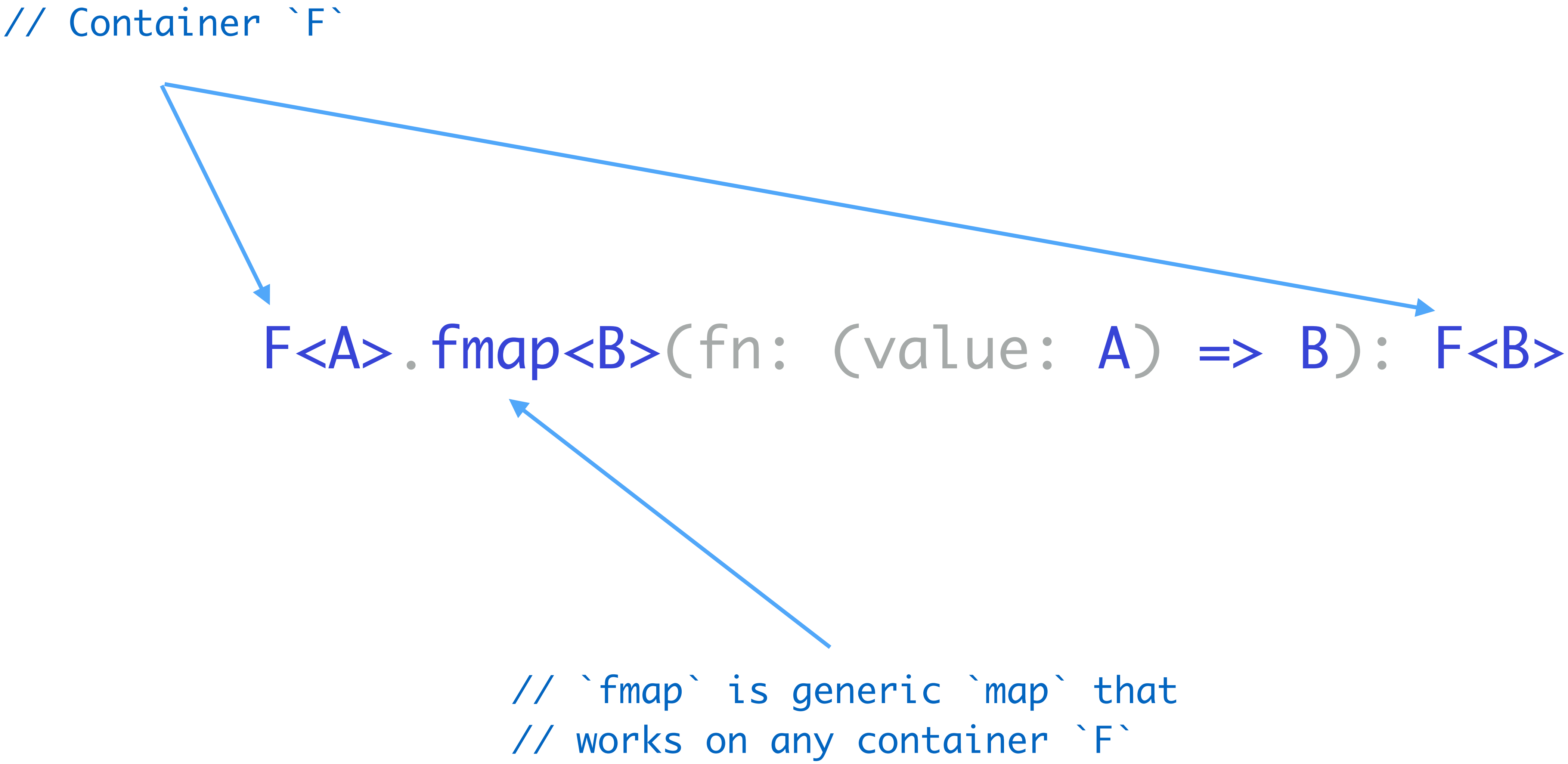
```haskell
main = do
  -- map :: (a -> b) -> [a] -> [b]
  print (map (\x -> x * 3) [1, 2, 3])
  -- [3, 6, 9]
```

```haskell
main = do
  -- map :: (a -> b) -> [a] -> [b]
  print (map (3*) [1, 2, 3])
  -- [3, 6, 9]
```

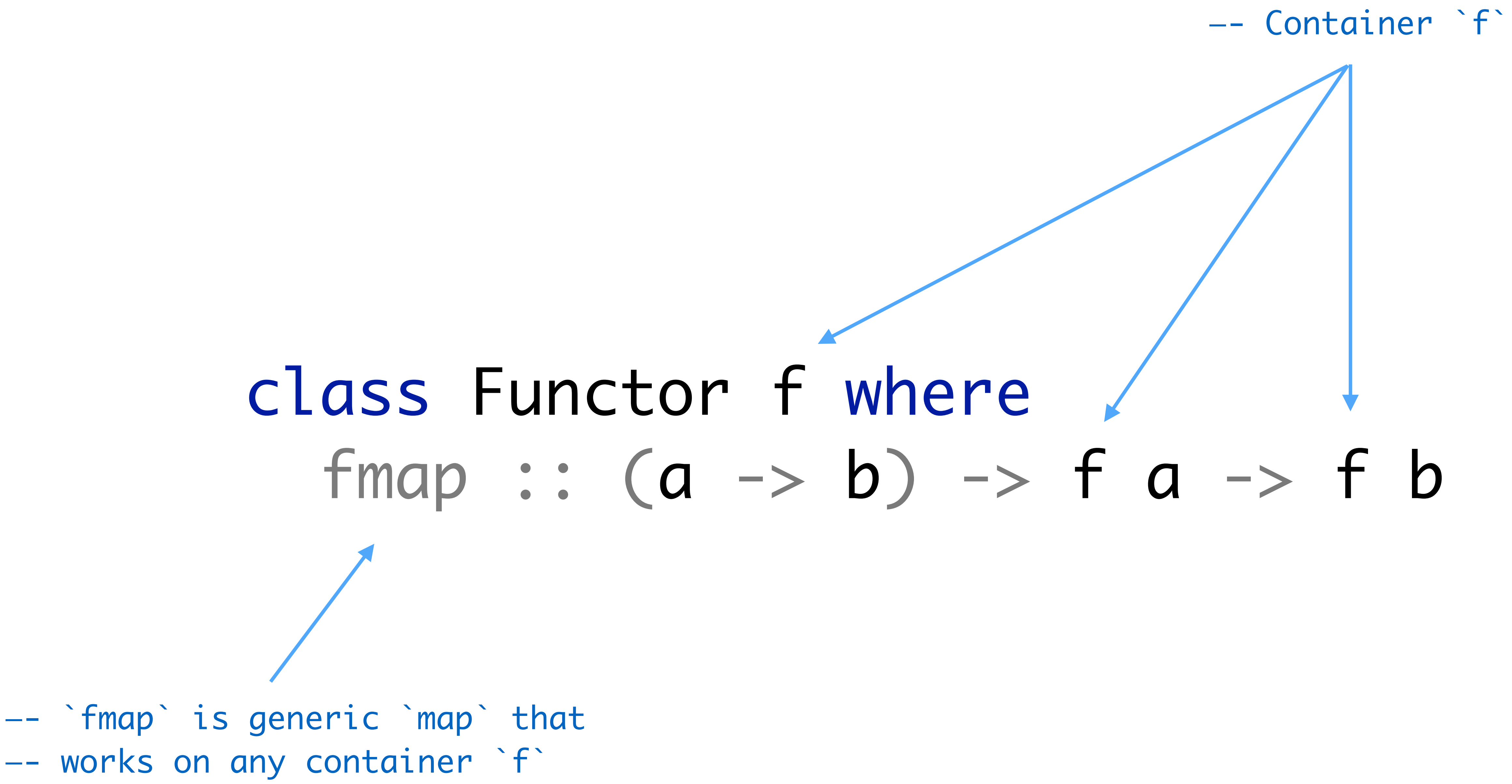
```haskell
main = do
  -- map :: (a -> b) -> [a] -> [b]
  print (map (3*) [1, 2, 3])
  -- [3, 6, 9]
```

```typescript
// Array<A>.map<B>(
//   fn: (value: A) => B
// ): Array<B>
console.log([1, 2, 3].map(x => x * 3))
// [3, 6, 9]
```

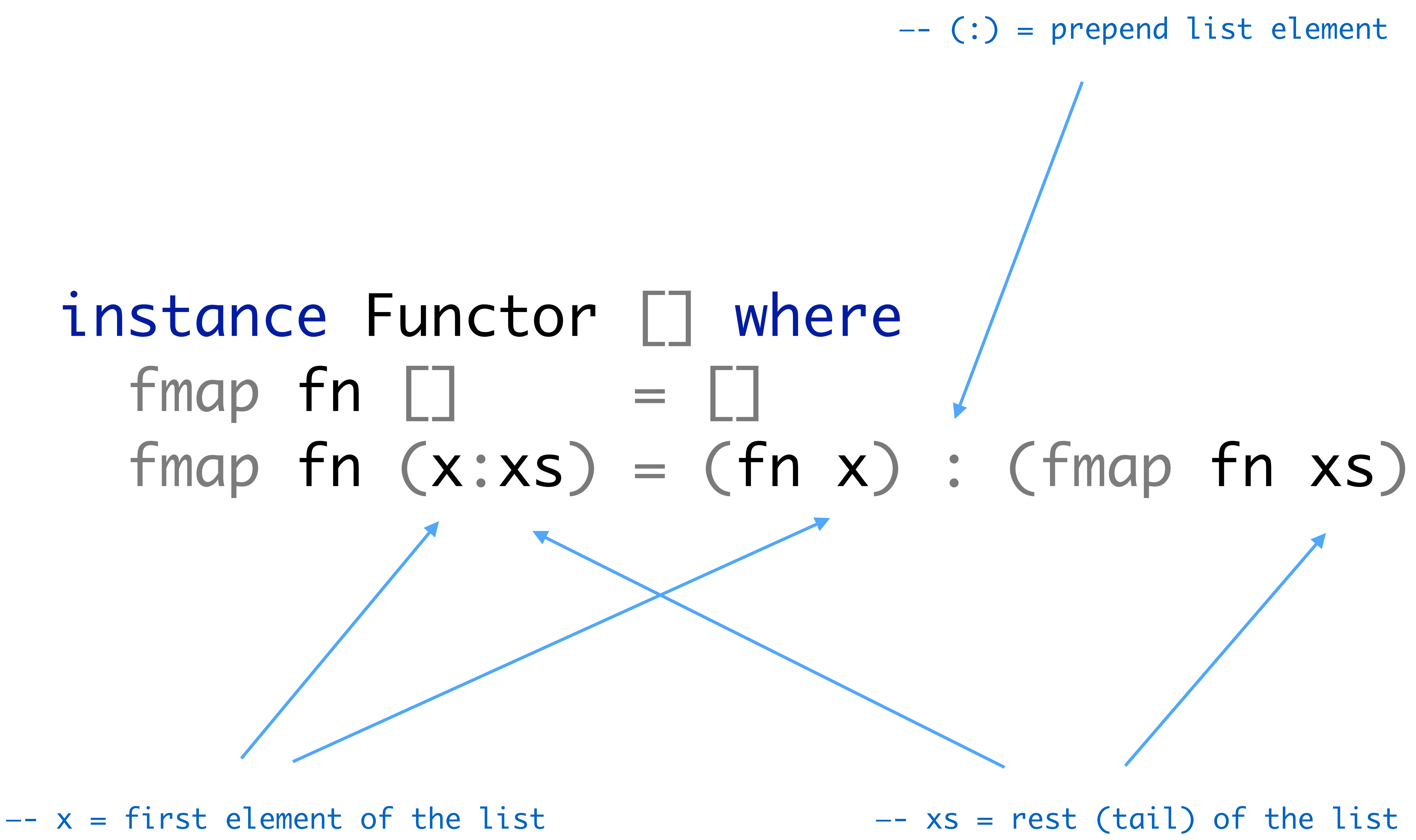
```
Array<A>.map<B>(fn: (value: A) => B): Array<B>
```



```
// Container `F`

F<A>.fmap<B>(fn: (value: A) => B): F<B>

// `fmap` is generic `map` that
// works on any container `F`
```



```haskell
-- Container `f`

class Functor f where
  fmap :: (a -> b) -> f a -> f b

-- `fmap` is generic `map` that
-- works on any container `f`
```



```
-- (:) = prepend list element
```

```haskell
instance Functor [] where
  fmap fn []     = []
  fmap fn (x:xs) = (fn x) : (fmap fn xs)
```

```
-- x = first element of the list
```

```
-- xs = rest (tail) of the list
```

```haskell
instance Functor [] where
   fmap = map
```

```haskell
instance Functor Maybe where
  fmap fn Nothing  = Nothing
  fmap fn (Just x) = Just (fn x)
```

```
main = do
  -- List
  print (fmap (3*) [1, 2, 3])
  -- > [3, 6, 9]

  -- Maybe
  print (fmap (3*) Nothing)
  -- > Nothing
  print (fmap (3*) (Just 2))
  -- > Just 6

  -- IO
  -- getLine :: IO String
  putStrLn "\nWhat is your name?"
  message <- fmap ("Hello, " ++) getLine
  putStrLn message
  -- > What is your name?
  -- > Daniel
  -- > "Hello, Daniel"

  -- Async
  putStrLn "\nSay something…"
  asyncPrompt <- async getLine
  asyncMessage <- wait (fmap ("Async: " ++) asyncPrompt)
  putStrLn asyncMessage
  -- > Say something…
  -- > Yo yo
  -- > Async: Yo yo
```

Conclusion

Expressive languages allow developers to describe better abstractions.

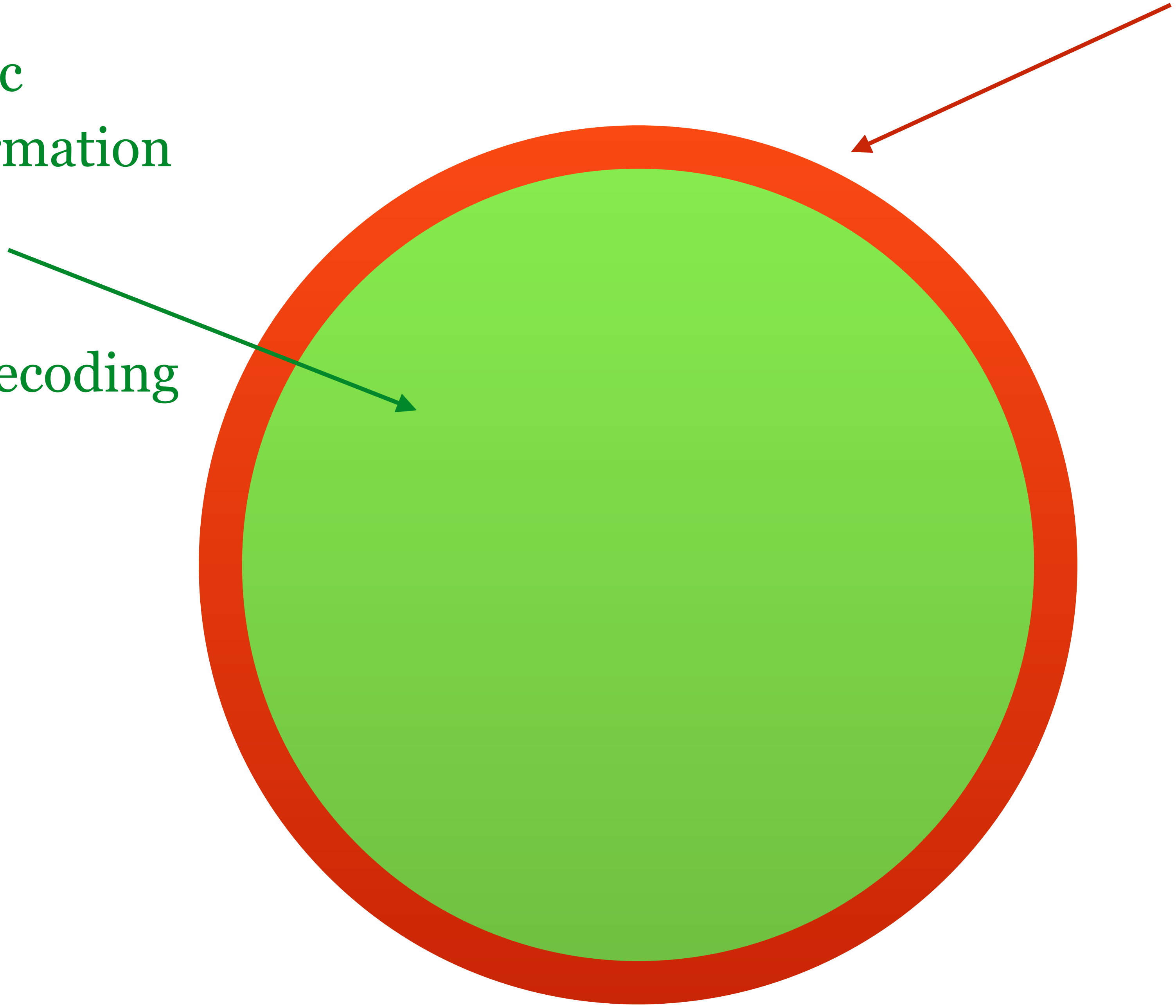
Type classes are a mechanism for abstracting common behaviors between different types.

Food for Thought

Impure Shell
&
Pure Core

Pure Core

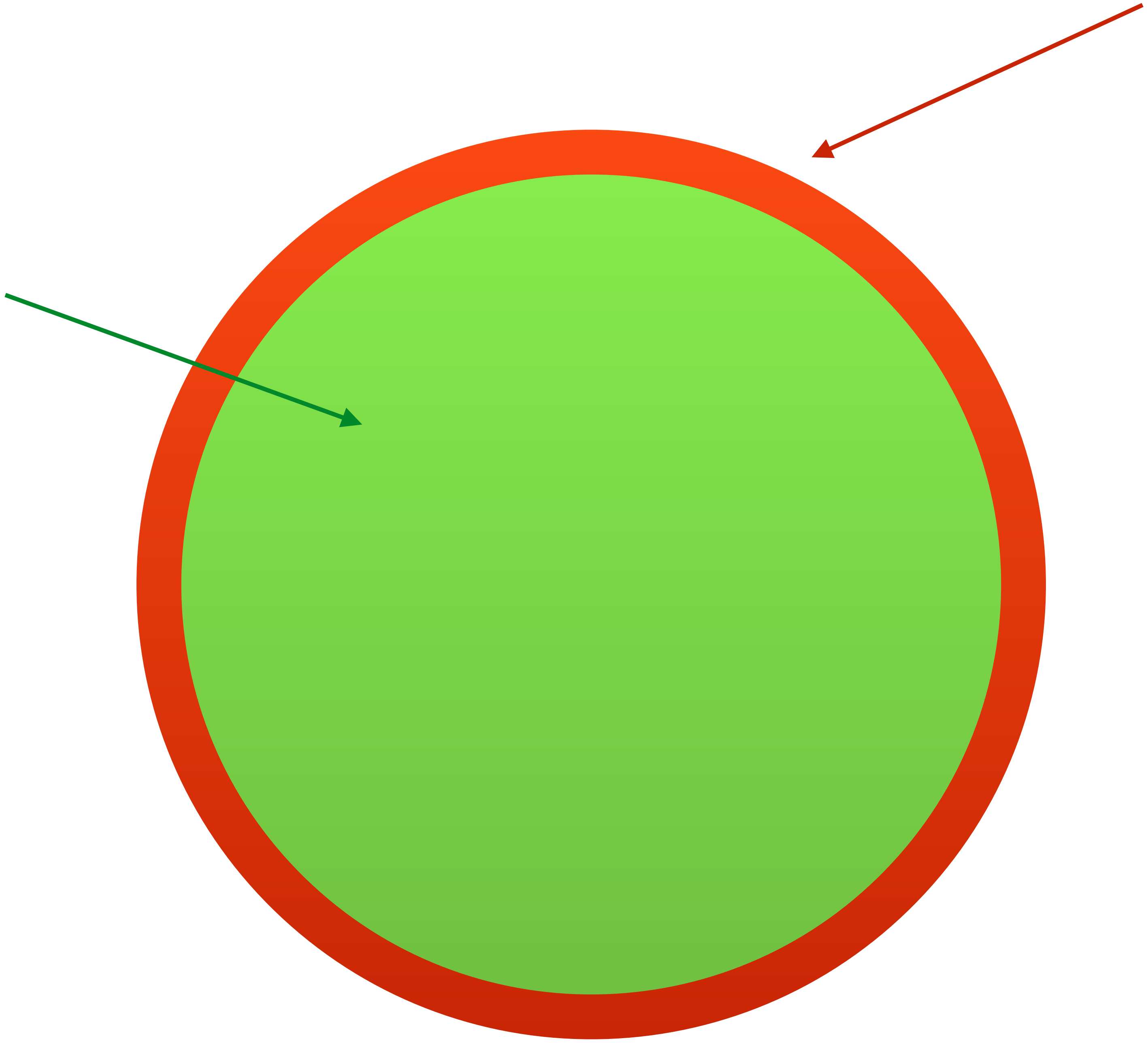
- business logic
- data transformation
- validation
- parsing
- encoding / decoding



Impure Shell

- user input
- networking
- file IO
- database
- randomness
- rendering

Example: Compiler



Pure Core

- lexical analysis
- syntax analysis
- type checking
- optimize code
- generate code

Impure Shell

- read CLI options
- read environment variables
- read source files
- write binary

PARENTAL

ADVISORY

CONTROVERSIAL CONTENT

Sound Foundation > Weak Ecosystem

Stay Hungry

“The only thing necessary for the triumph of [bad technology] is for good men to do nothing.”

Q&A

“All [bad technology] needs to gain a foothold is for people of good conscience to remain silent.”