SpecCheck: Monadic specification and property based testing of typed communication protocols

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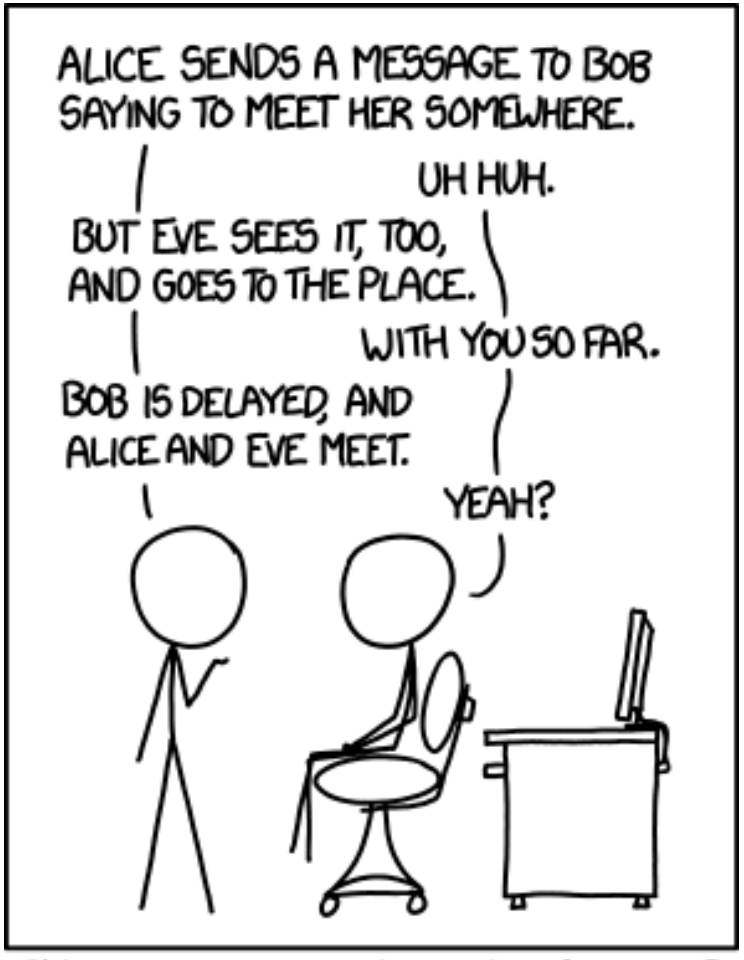
The problem

Building correct distributed applications



The problem, simplified

Bulding correct client-server applications

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- Specification
- Test-suite
- Update the specification
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Server

- Specification
- Test-suite
- Update the specification
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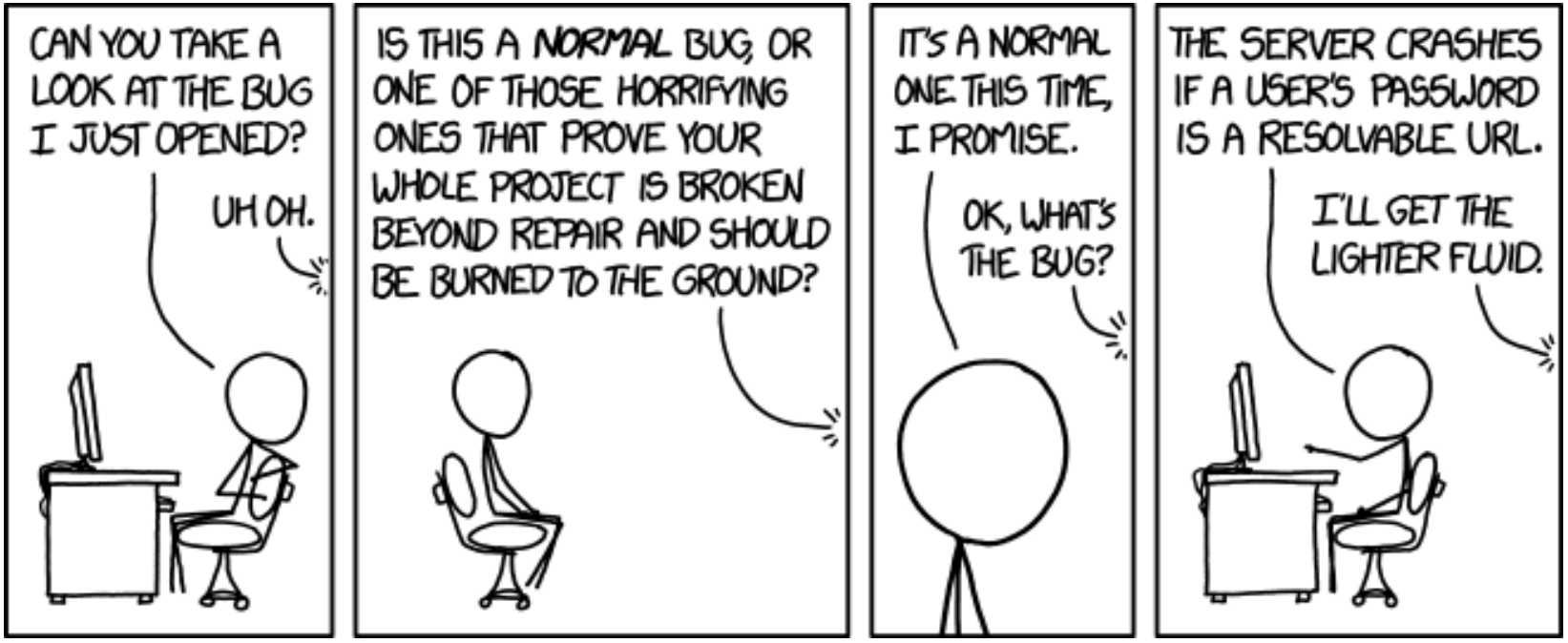
The solution

SpecCheck, the "elevator pitch"

- Write *one* specification
- Property based testing



Demo!

The interface

```
send   :: (a :<: t) => Predicate a -> Spec t a

get    :: (a :<: t) => Predicate a -> Spec t a

choose :: (Eq a, a :<: t) => [a] -> Spec t a

branch :: (Eq a, a :<: t) => [a] -> Spec t a

dual   :: Spec t a -> Spec t a
```

How does it work?

```
data Sop m c where
  Send    :: a :<: c (...) =>
         Predicate a -> (a -> m IO (Sop m c)) -> Sop m c
  Get     :: a :<: c (...) =>
         Predicate a -> (a -> m IO (Sop m c)) -> Sop m c
  End     :: Sop m c

type Predicate a = (Gen a, a -> Bool)

type SpecT m t a = ContT (Sop m t) (m IO) a

type Spec t a = forall m. SpecT m t a

type SpecS st t a = SpecT (StateT st) t a
```

Duality

```
dual (get p)     = send p
dual (send p)    = get p
dual stop        = stop
dual (m >>= f)   = dual m >>= (dual . f)
dual (return a) = return a
```

Duality in action!

```
game = do
  move     <- send validMove
  gameOver <- updateGameState move
  if gameOver then
    stop
  else
    dual game
```

Shrinking

Shrinking

- Number of messages
- Size of the messages

```
Sent: -14
Sent: "another"
Sent: -2
Sent: "request"
Got:  []
```

shrinks to

```
Sent: 0
Sent: "request"
Got:  []
```

Counterexamples in QuickCheck

```
Main*> let prop_reverse xs ys =
         reverse (xs ++ ys) == reverse xs ++ reverse ys
Main*> quickCheck prop_reverse
*** Failed! Falsifiable (...):
  [0]
  [1]
```

Counterexamples in SpecCheck

```haskell
data Interaction c = Got c
                   | Sent c
type Log c = [Interaction c]
```

```
Sent: -14
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```

How does it work?

- Cant' do anything about `Got`
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The naïve algorithm

- Try to follow the `Log`
- Default to random
- If the resulting trace is longer than the current trace, discard it.
- Repeat lots of times...

Revisiting predicates

```
type Predicate a = (a -> Bool, Gen a, a -> Gen a)
```

Demo!

Inconsistent specifications

Inconsistent specifications

```
inconsistent = do
  n1 <- send posNum
  n2 <- send negNum
  get (inRange (n1, n2))
```

```
Failed with inability
to generate: inRange (11,-12)
In:
---
  Sent: 11
  Sent: -12
```

How does it work?

In theory:

- Run specification against itself (duality!)
- Detect when a predicate is unsat

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In theory:

- Run specification against itself (duality!)
- Detect when a predicate is unsat

In practise:

- Can't detect partiality in `Gen`... (Maybe `Idris`?)
- Timeout!
- Shrinking is a problem

Generator predicate pairs

- Laziness works well for some things, less well for other things...
- Current solution: ad-hoc...
- Better solution (?): Logic programming

Some other things

- Automatically create examples of communication
- Specifications parameterized by bugs in the implementation

Summary

- Shrinking is a hard problem
- Duality $\rightarrow$ we only need *one* specification
- Duality $\rightarrow$ find inconsistencies

Future work

- Asynchronous protocols
- Multiparty communication
- Protocol stacks
- A language for writing generator predicate pairs in Haskell

Questions?