# SAFE HASKELL

David Terei
David Mazières

Stanford University

Simon Marlow
Simon Peyton Jones

Microsoft Research

# MOTIVATION

Haskell is a great language for building secure systems in:

- Information flow control
- Capabilities
- Computations on encrypted data

But all this work can't secure untrusted code in the real world!

# MOTIVATION

**Running Example:**

Build in Haskell a website that can run untrusted third-party plugins:

- Users can upload plugins in source form
- Any user can install an uploaded plugin against their account

# MOTIVATION

How?

- Carefully craft plugin interface to restrict functions that a plugin can execute
  - e.g Only pure functions
- Need type safety guarantees for this to work

# MOTIVATION

```
f :: a -> a
```

# MOTIVATION

```
f :: a -> a
```

```
f a = unsafePerformIO $ do
        _ <- send_credit_card
        return a
```

# SOLUTION?

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Safe Haskell !

# SAFE HASKELL

- Safe subset of Haskell that provides 'enough' guarantees
- A *safe import* extension
- A definition of *trust* that applies to modules and packages

# SAFE LANGUAGE

- Safe language (enabled with -XSafe) provides:
    - Type safety
    - Guaranteed module boundaries
    - Semantic consistency
- These are the properties that we usually think about Haskell having
- Safe language is a subset of Haskell

# -XSAFE RESTRICTIONS

- FFI imports must be in the IO monad
- Can't define RULES
- No Template Haskell
- No GeneralizedNewtypeDeriving
- No hand crafted instances of Data.Typeable, only derived
- Overlapping instances can only overlap instances defined in the same module
- Can only import other '*trusted*' modules

# REVISITING THE EXAMPLE

- So for untrusted plugins, compile with -XSafe
- Can craft a plugin interface that uses types carefully to control functions a plugin can execute

Done?

# TURTLES ALL THE WAY DOWN

- -XSafe compiled modules can only import trusted modules
- So far -XSafe is only way to create trusted modules
- What about modules like Data.ByteString?
  - Want to allow untrusted code to use Data.ByteString
  - Unsafe internals but safe API

# -XTRUSTWORTHY

Allows a module author to declare:

*'While module M may use unsafe functions internally, it only exposes a safe API'*

# -XTRUSTWORTHY

- No restrictions on Haskell language
- Marks a module as trusted though
- Module author should assure that type safety can't be violated by importing their module
- Enables a small extension called safe imports

# WHAT IS TRUST?

- What determines if a module is considered 'trusted'?
  - -XSafe compiled modules
- What about -XTrustworthy modules?

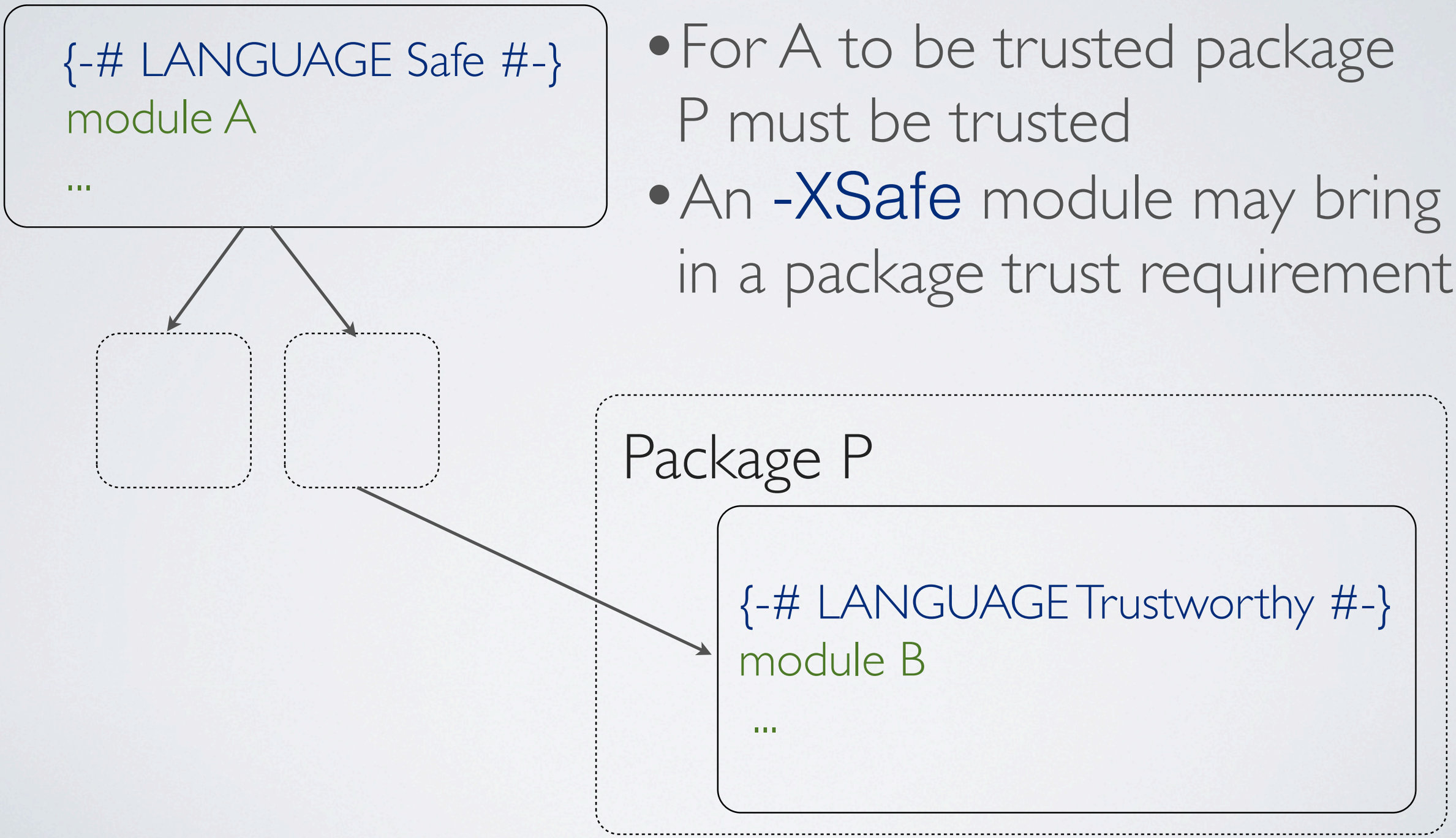
# WHAT IS TRUST?

- -XTrustworthy allows a module author to mark any module as potentially 'trusted'
- Very easy to abuse
- So we require that the client (person running the compiler) assert that they trust the module author by stating they trust the package
- For example:
  - Don Stewart marks Data.Bytestring as Trustworthy
  - Untrusted plugin author imports and uses Data.Bytestring
  - Website administrator marks the bytestring package as *trusted*

# WHAT IS TRUST?

- For -XSafe:
  - trust provided by *compiler*
- For -XTrustworthy:
  - trust of module stated by *module author*
  - trust of module author provided by *client* by trusting the package the module resides in

# TRUST IS TRANSITIVE




- For A to be trusted package P must be trusted
- An -XSafe module may bring in a package trust requirement

# PACKAGE TRUST

- ghc-pkg *trust <pkg>*
- ghc-pkg *distrust <pkg>*
- ghc *-trust <pkg> ...*
- ghc *-distrust <pkg> ...*
- ghc *-distrust-all-packages ...*

# SAFE IMPORTS

- One extension to the Haskell language:

```
import safe M
```

- Allows module author to specify that M must be *trusted* for the import to succeed

- Under -XSafe all imports are safe imports (keyword implicit)

- Under -XTrustworthy the module author can choose

# PROBLEMS WITH 7.2

- Current description is of Safe Haskell in 7.2
- Issue with operation of package trust
  - Causes Safe Haskell to be invasive, infect the world!

# BUILD ERRORS

*"I'm running into a lot of issues like the following:*

*libraries/hoopl/src/Compiler/Hoopl/Collections.hs:14:1:*

*base:Data.List can't be safely imported! The package (base) the module resides in isn't trusted."*

# PACKAGE TRUST REIFIED

- In *7.4*, we won't require that the package a Trustworthy module resides in be trusted for the compilation to succeed

- -XTrustworthy modules will simply be trusted by default

- New *-fpackage-trust* flag to enable old behavior of *7.2*

  - This flag *should always* be used if you are compiling untrusted code

# SAFE INFERENCE

Unreasonable to expect the Haskell world to all start putting explicit -XSafe and -XTrustworthy pragmas in their files.

So in *7.4*:

- Safe status of a module will be inferred
- New -XUnsafe flag to explicitly mark a module as unsafe so that it can't be imported by untrusted code

# RUNNING EXAMPLE

```
{-# LANGUAGE Unsafe #-}
module RIO.Unsafe ( RIO(..) ) where

newtype RIO a = UnsafeRIO { runRIO :: IO a }
instance Monad RIO where
    return = UnsafeRIO . return
    (UnsafeRIO m) >>= k = UnsafeRIO $ m >>= runRIO . k
```

```
{-# LANGUAGE Trustworthy #-}
module RIO.FileAccess ( rioReadFile, rioWriteFile ) where
...
pathOK f = {- Implement some policy -}

rioReadFile :: FilePath -> RIO String
rioReadFile f = UnsafeRIO $ do
    ok <- pathOK f
    if ok then readFile f else return “”

rioWriteFile :: FilePath -> String -> RIO ()
rioWriteFile f s = ...
```

# RUNNING EXAMPLE

```
{-# LANGUAGE Trustworthy #-}

module RIO ( RIO() , runRIO, rioReadFile, rioWriteFile ) where

import RIO.Unsafe

import safe RIO.FileAccess
```

```
{-# LANGUAGE Safe #-}

module UntrustedPlugin ( runPlugin ) where

import RIO


runPlugin :: RIO ()

runPlugin = ...
```

# SUMMARY

- New language flags: -XSafe, -XTrustworthy, -XUnsafe
- New option flag: -fpackage-trust (*7.4*)
- Safe status of a module will be inferred (*7.4*)

*Trust your types!*

# FUTURE WORK

- Prove safety guarantees
- Establish clearer definition of safe and what guarantees trustworthy modules should provide
  - Machine checking possible here?
- Do a retake on Safe language but by starting with a small, proven correct core and expanding out.
  - Inclusion in the Safe language could be used as a quality bar for new Haskell extensions.
  - Require formal semantics and proofs

# SAFE HASKELL

In GHC 7.2

Please try out and provide feedback

http://www.scs.stanford.edu/~davidt/safehaskell.html