Rank-N Types Are Freakin' Sweet

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Rank N Types

- Are awesome
- Require understanding polymorphism in Haskell a bit first
- So this talk doesn't really start at Rank-N types.

Polymorphism

```
id   ::            a -> a
(+1) :: Num a => a -> a
(+1) ::          Int -> Int
```

Universal quantification

The type of identity can be read as,

```
id :: forall a . a -> a
```

For **all** *a*, *a* to *a*

Binders for type variables

It turns out, our binders for types behave a lot like lambdas.

```
forall x . x
\x -> x
```

This is how we bind variables to concrete types, characterize polymorphism.

Rank-1

This is what Haskell type signatures all default to.

Prenex-form is “outermost left-most”.

Prenex form

Means that when Haskell fills in the “forall” for you, this:

```
a -> b -> a
```

Turns into:

```
forall a b . a -> b -> a
```

Currying still applies

WHEN DID THIS

```
forall a b . a -> b -> a
```

BECOME MORE BEAUTIFUL THAN THIS?

```
forall a. a -> (forall b. b -> a)
```

But yeah, same deal.

```
forall a b . a -> b -> a
-- equivalent.
forall a. a -> (forall b. b -> a)
```

ExplicitForAll

That was real syntax! You can write the foralls yourself!

```
{-# LANGUAGE ExplicitForAll #-}

length :: forall a . a -> Int
length = ...
```

It seems like this should work

`tuple.hs`

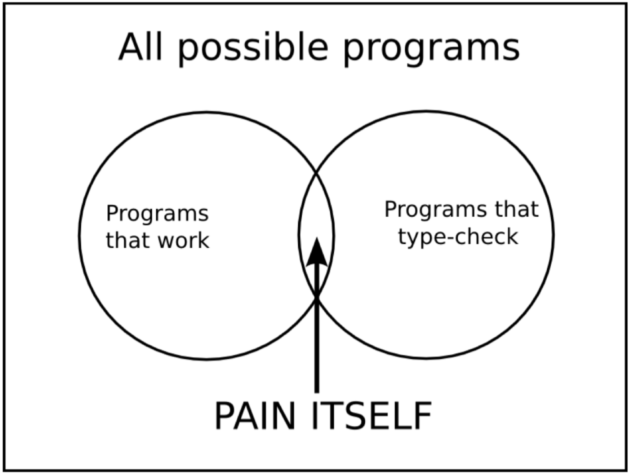
Tension!

A tension between what terms can be permitted in our type system and what badness we can prevent.

Morality and legality are orthogonal

There are programs we can write which are valid, but which a type system will reject. Part of PL and type theory research is making this valid-but-illegal space as small as possible.

Bad type system

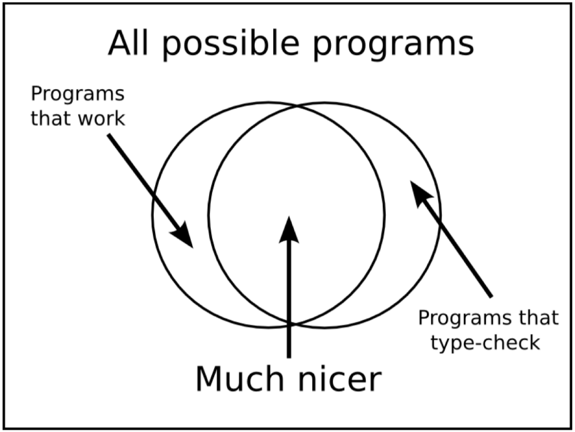


Why pain? Because the overlap is so small!

Figure 1:This type system is pain itself

Good type system

CHAPTER 5. TYPES 147



The above is an example of what we would actually like, a type system which, as much as is possible, lets us only express programs that work and express *many* possible working programs.

Figure 2:This type system is much nicer

Rank-2

Higher rank polymorphism expansionism

Higher rank polymorphism expands what our type system permits us to say, without any cost in correctness.

Examples from lens

```
{-# LANGUAGE Rank2Types #-}

type Lens s t a b =
  forall f . Functor f => (a -> f b) -> s -> f t
```

Rank-N

`ranks.hs`