Visible Dependent Quantification

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Haskell Implementors Workshop
23 August 2019
Berlin, Germany

VDQ

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The origins of VDQ

Syntax for visible dependent quantification #81

Merged **nomeata** merged 6 commits into `ghc-proposals:master` from `goldfirere:forall-arrow` on Sep 30, 2018

Conversation 44 Commits 6 Checks 0 Files changed 1

goldfirere commented on Oct 13, 2017 • edited by nomeata Contributor

The proposal has been accepted; the following discussion is mostly of historic interest.

This proposes a concrete syntax for a kind that has existed since GHC 8.0, but cannot currently be parsed.

Rendered

Syntax for visible dependent quantification #81

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a kind that has existed since GHC 8.0, but cannot currently be parsed.

The proposal has been accepted; the following discussion is mostly of historic interest.

This proposes a concrete syntax for a kind that has existed since GHC 8.0, but cannot currently be parsed.

Rendered

```
data Bool where
  False :: Bool
  True  :: Bool
```

```
data Bool where
  False :: Bool
  True  :: Bool

data Bool :: * where
  ...
```

```
data Bool where
  False :: Bool
  True  :: Bool

data Bool :: Type where
  ...
```

```haskell
data Maybe a where
  Nothing :: Maybe a
  Just    :: a -> Maybe a
```

```haskell
data Maybe a where
  Nothing :: Maybe a
  Just    :: a -> Maybe a

data Maybe :: Type -> Type where
  ...
```

```
data Proxy (a :: k) where
  MkProxy :: Proxy a
```

```haskell
data Proxy (a :: k) where
  MkProxy :: Proxy a

data Proxy :: k -> Type where
  ...
```

```haskell
data Proxy (a :: k) where
  MkProxy :: Proxy a

data Proxy :: forall k. k -> Type where
  ...
```

```
data ProxyExp k (a :: k) where
  MkProxyExp :: ProxyExp k (a :: k)
```

```
data ProxyExp k (a :: k) where
  MkProxyExp :: ProxyExp k (a :: k)


data ProxyExp :: ??? where
  ...
```

New in GHC 8.0!

```haskell
data ProxyExp k (a :: k) where
  MkProxyExp :: ProxyExp k (a :: k)
```

New in GHC 8.0!

```
$ ghci
λ>
```

```haskell
data ProxyExp k (a :: k) where
  MkProxyExp :: ProxyExp k (a :: k)
```

New in GHC 8.0!

```
$ ghci
λ> :kind ProxyExp
```

```
data ProxyExp k (a :: k) where
  MkProxyExp :: ProxyExp k (a :: k)
```

New in GHC 8.0!

```
$ ghci
λ> :kind ProxyExp
ProxyExp :: forall k -> k -> Type
```

```haskell
data ProxyExp k (a :: k) where
  MkProxyExp :: ProxyExp k (a :: k)
```

New in GHC 8.0!

```
$ ghci
λ> :kind ProxyExp
ProxyExp :: forall k -> k -> Type
λ> data ProxyExp :: forall k -> k -> Type
```

```
data ProxyExp k (a :: k) where
  MkProxyExp :: ProxyExp k (a :: k)
```

New in GHC 8.0!

```
$ ghci
λ> :kind ProxyExp
ProxyExp :: forall k -> k -> Type
λ> data ProxyExp :: forall k -> k -> Type

<interactive>:11:27: error: parse error on
input ‘->’
```

What is this `forall k ->` thing, anyway?

Visible Dependent Quantification

Visible Dependent Quantification

Visible Dependent

The argument *must* be written in the source code.

Visible Dependent Quantification

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```
  Maybe
:: Type -> Type
```

Visible Dependent

The argument *must* be written in the source code.

```
  Maybe
:: Type -> Type
  -----
Maybe Int
```

Visible Dependent Quantification

The argument *must* be written in the source code.

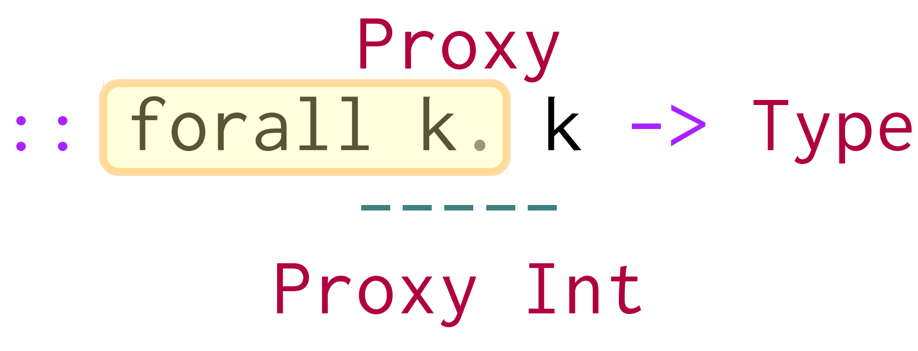
```
    Maybe
:: Type -> Type
    -----
  Maybe Int
```

```
         Proxy
:: forall k. k -> Type
```

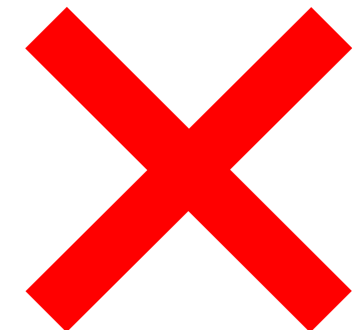
Visible Dependent Quantification

The argument *must* be written in the source code.

```
    Maybe
:: Type -> Type
   ------
  Maybe Int
```



```
       Proxy
:: forall k. k -> Type
       ------
     Proxy Int
```



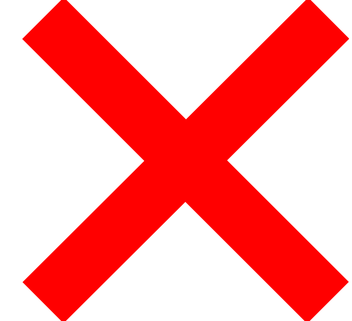
Visible Dependent

The argument *must* be written in the source code.

```
Maybe
:: Type -> Type
------
Maybe Int
```

```
Proxy
:: forall k. k -> Type
------
```

```
Proxy @Type Int
```



Visible Dependent Quantification

Visible **Dependent** Quantification

Visible Dependent Quantification

The body of the kind changes depending on its type.

Visible Dependent

The body of the kind changes depending on its type.

```
Proxy
:: forall k. k -> Type
```

Visible **Dependent** Quantification

The body of the kind changes depending on its type.

```
        Proxy
:: forall k. k -> Type
```

Visible Dependent Quantification

The body of the kind changes depending on its type.

```
          Proxy
  :: forall k. k -> Type
          ------
Proxy @Type :: Type -> Type
```

Visible **Dependent**

The body of the kind changes depending on its type.

```
          Proxy
   :: forall k. k -> Type
          -----
Proxy @()  :: ()      -> Type
```

Visible Dependent Quantification

The body of the kind changes depending on its type.

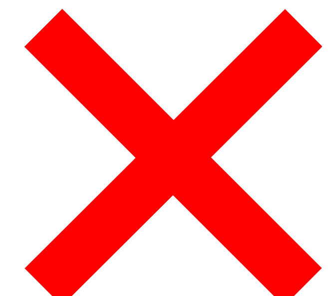
```
          Proxy
   :: forall k. k -> Type
          ------
Proxy @Bool :: Bool -> Type
```

Visible **Dependent**

The body of the kind changes depending on its type.

```
      Proxy
:: forall k. k -> Type
      -----
Proxy @Bool :: Bool -> Type
```

```
   Maybe
:: Type -> Type
```

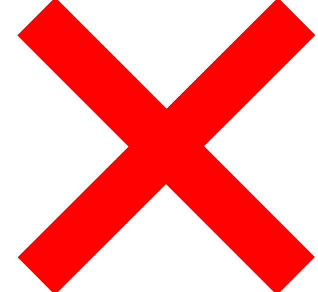


Visible Dependent

The body of the kind changes depending on its type.

```
      Proxy
 :: forall k. k -> Type
      ------
Proxy @Bool :: Bool -> Type
```

```
      Maybe
 :: Type -> Type
      ------
Maybe Int  :: Type
```



Visible Dependent

The body of the kind changes depending on its type.

```
Proxy
:: forall k. k -> Type
------
Proxy @Bool :: Bool -> Type
```

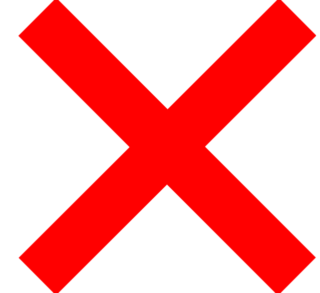
```
Maybe
:: Type -> Type
------
Maybe Char :: Type
```

Visible Dependent

The body of the kind changes depending on its type.

```
     Proxy
:: forall k. k -> Type
     ------
Proxy @Bool :: Bool -> Type
```

```
     Maybe
:: Type -> Type
     ------
Maybe Bool :: Type
```



Visible Dependent Quantification

Visible Dependent Quantification

```
data ProxyExp :: forall k -> k -> Type
```

Visible Dependent Quantification

```
data ProxyExp :: forall k -> k -> Type
```

Visible Dependent Quantification

```
data ProxyExp :: forall k -> k -> Type
```

Visible Dependent Quantification

```
data ProxyExp :: forall k -> k -> Type
                 ------
     ProxyExp Bool
```

Visible Dependent Quantification

```
data ProxyExp :: forall k -> k -> Type
                 ------
    ProxyExp Bool :: Bool -> Type
```

Visible Dependent Quantification

```
data ProxyExp :: forall k -> k -> Type
                 ------
ProxyExp Type :: Type -> Type
```

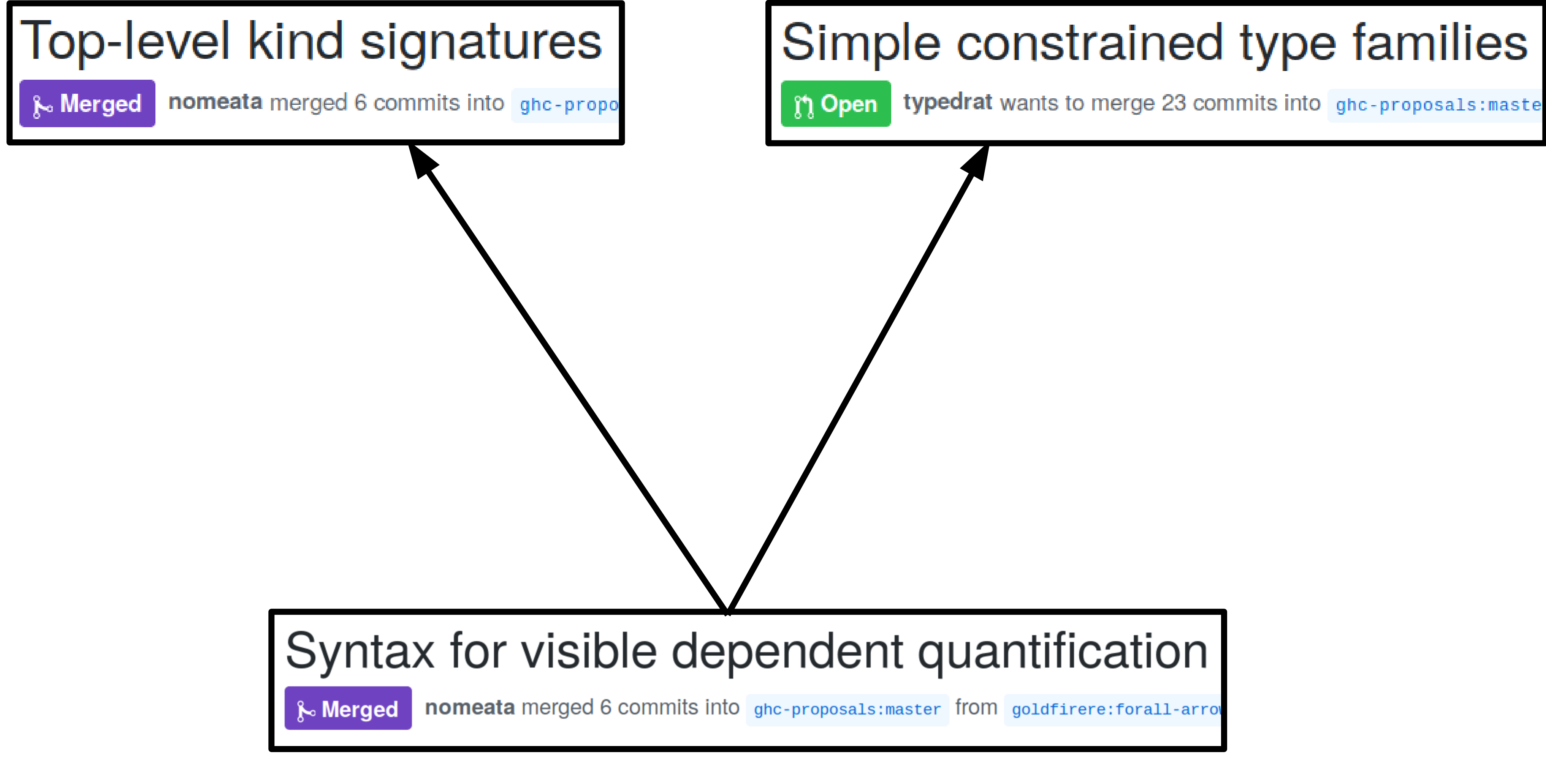
Visible Dependent Quantification

```
data ProxyExp :: forall k -> k -> Type
                 ------
     ProxyExp ()    :: ()    -> Type
```

Why do I want this?

Syntax for visible dependent quantification

Merged **nomeata** merged 6 commits into `ghc-proposals:master` from `goldfirere:forall-arro`


Top-level kind signatures
Merged
nomeata merged 6 commits into ghc-propo
Simple constrained type families
Open
typedrat wants to merge 23 commits into ghc-proposals:maste
Syntax for visible dependent quantification
Merged
nomeata merged 6 commits into ghc-proposals:master from goldfirere:forall-arro

Top-level kind signatures

Merged nomeata merged 6 commits into `ghc-propo`

Top-level kind signatures

Merged nomeata merged 6 commits into ghc-propo

```
type T :: (k -> Type) -> k -> Type
data T m a =
  MkT (m a) (T Maybe (m a))
```

Top-level kind signatures

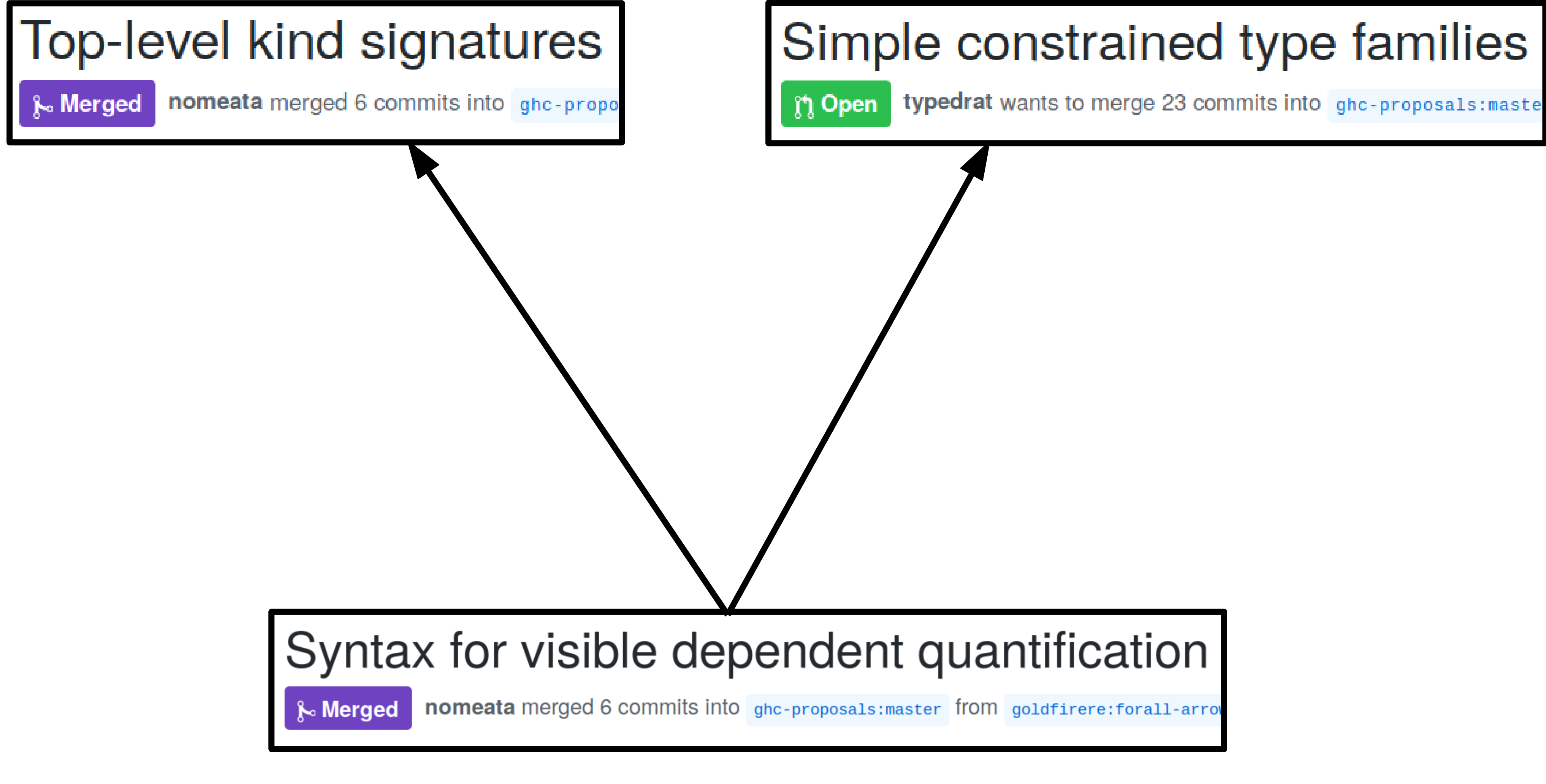
Merged nomeata merged 6 commits into ghc-propo

```
type T :: (k -> Type) -> k -> Type
data T m a =
  MkT (m a) (T Maybe (m a))


data T2 k m (a :: k) =
  MkT2 (m a) (T2 Type Maybe (m a))
```

Top-level kind signatures

Merged nomeata merged 6 commits into ghc-propo

```
type T :: (k -> Type) -> k -> Type
data T m a =
  MkT (m a) (T Maybe (m a))

type T2 :: forall k -> (k -> Type) -> k -> Type
data T2 k m (a :: k) =
  MkT2 (m a) (T2 Type Maybe (m a))
```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Syntax for visible dependent quantification
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Simple constrained type families

Open typedrat wants to merge 23 commits into `ghc-proposals:maste`

Simple constrained type families

Open typedrat wants to merge 23 commits into ghc-proposals:maste

```
class C a where
  type T a
```

Simple constrained type families

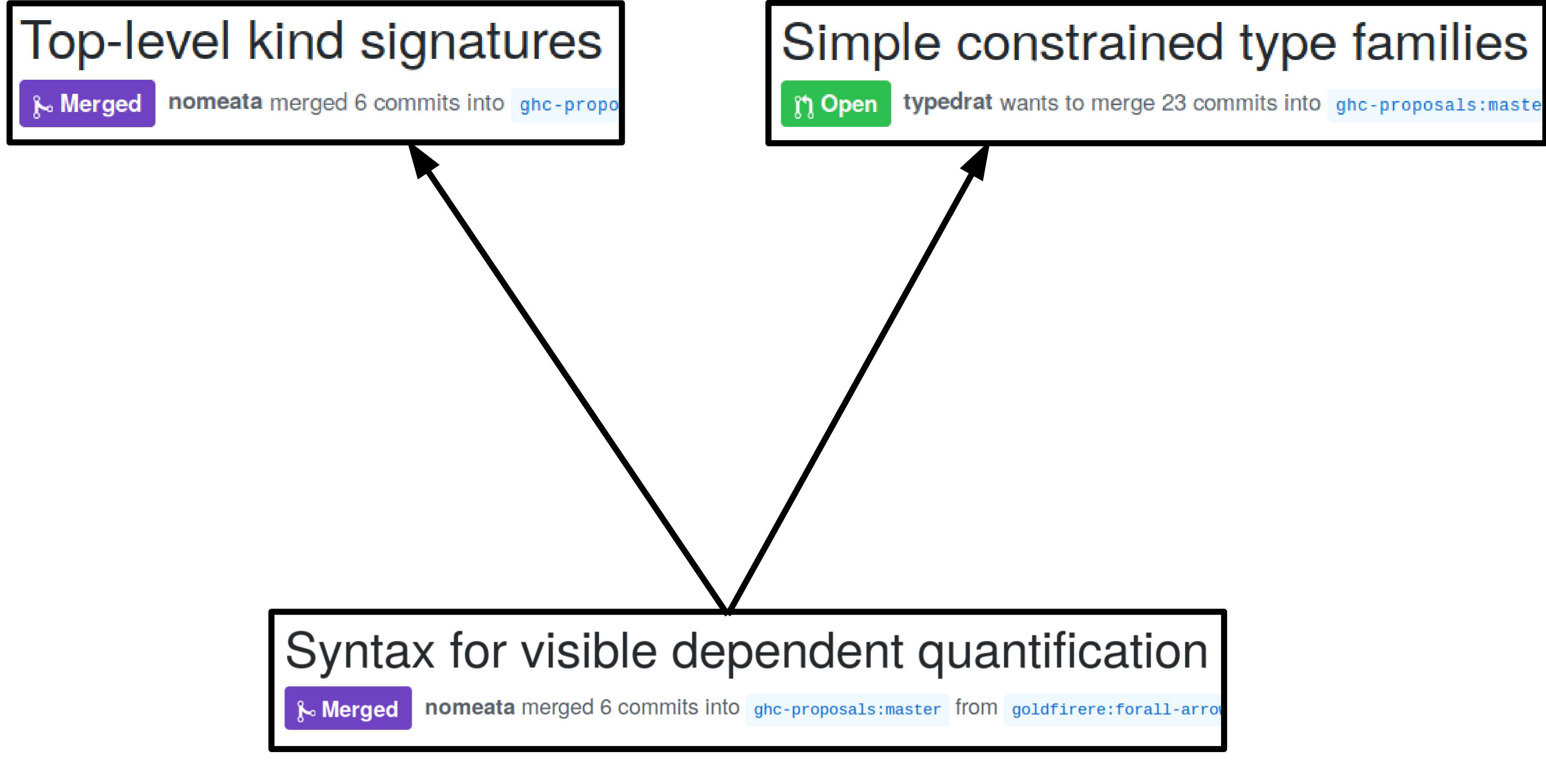
Open typedrat wants to merge 23 commits into ghc-proposals:maste

```
class C a where
  type T a

T :: Type -> Type -- Old kind
```

Simple constrained type families

Open typedrat wants to merge 23 commits into ghc-proposals:maste

```
class C a where
  type T a

T :: Type -> Type -- Old kind
T :: forall (a :: Type) -> C a => Type
                   -- New kind
```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Top-level kind signatures

Merged nomeata merged 6 commits into ghc-propo

Simple constrained type families

Open typedrat wants to merge 23 commits into ghc-proposals:maste

Dependent Haskell? #???

I dunno someone probably wants to merge 23 comm

Syntax for visible dependent quantification

Merged nomeata merged 6 commits into ghc-proposals:master from goldfirere:forall-arro

```
_$_ :  ∀ {A : Set} {B : Set} →
       (A → B) →
       (A → B)
f $ x = f x
```

```
_$_ :  ∀ {A : Set} {B : A → Set} →
      (∀ (x : A) → B x) →
      (∀ (x : A) → B x)
f $ x = f x
```

```
_$_ :  ∀ {A : Set} {B : A → Set} →
       (∀ (x : A) → B x) →
       (∀ (x : A) → B x)
f $ x = f x

type ($) :: forall (a :: Type) (b :: a -> Type).
            (forall (x :: a) -> b x) ->
            (forall (x :: a) -> b x)
type f $ x = f x
```

```
_$_ :  ∀ {A : Set} {B : A → Set} →
       (∀ (x : A) → B x) →
       (∀ (x : A) → B x)
f $ x = f x
```

```
{-# LANGUAGE UnicodeSyntax #-}
type ($) :: ∀ (a :: Type) (b :: a → Type).
            (∀ (x :: a) → b x) →
            (∀ (x :: a) → b x)
type f $ x = f x
```

Implementing VDQ

Glasgow Haskell Compiler › GHC › Commits › **c26d299d**

Dec 18, 2018 1:54am

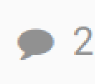
Commit c26d299d authored 7 months ago by **Ryan Scott** Committed by **Marge Bot** 4 months ago

Visible dependent quantification

> This implements GHC proposal 35
> (https://github.com/ghc-proposals/ghc-proposals/blob/master/proposals/0035-forall-arrow.rst)
> by adding the ability to write kinds with
> visible dependent quantification (VDQ).

Glasgow Haskell Compiler > GHC > Commits > c26d299d

Dec 18, 2018 1:54am

Commit c26d299d authored 7 months ago by **Ryan Scott** Committed by **Marge Bot** 4 months ago 

Visible dependent quantification

> This implements [obscured]
> (https://github.[obscured] arrow.rst)
> by adding the ab[obscured]
> visible dependent quantification (VDQ).

Showing **64 changed files** with **814 additions** and **149 deletions**

```
data T (a :: Type) :: Type
```

```
data T (a :: Type) :: Type

T :: Type -> Type
```

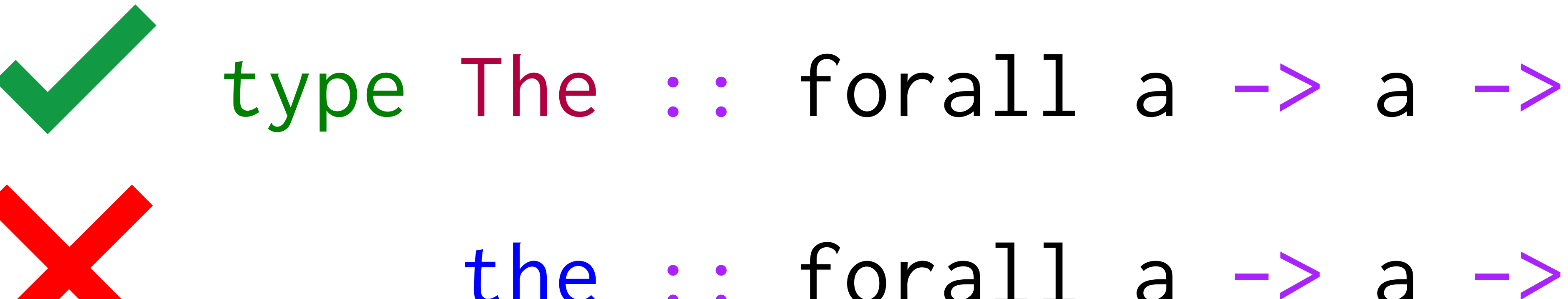
```haskell
data T (a :: Type) :: Type

T :: Type -> Type
T :: forall (a :: Type) -> Type
```

```
data T (a :: Type) :: Type

T :: Type -> Type
T :: forall (a :: Type) -> Type
```

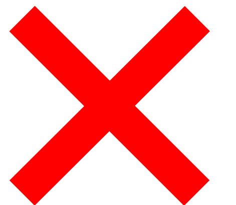
```
data T (a :: Type) :: Type

T :: Type -> Type
T :: forall (a :: Type) -> Type
```

These two kinds are *not* equivalent (currently)

```
type The :: forall a -> a -> a
     the :: forall a -> a -> a
```


type The :: forall a -> a -> a
the :: forall a -> a -> a

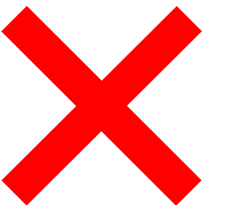
```
type The :: forall a -> a -> a
```



```
the :: forall a -> a -> a
```

```
λ> the :: forall a -> a -> a
```

```
type The :: forall a -> a -> a
```



```
the :: forall a -> a -> a
```

```
λ> the :: forall a -> a -> a
<interactive>:7:8: error:
    • Illegal visible, dependent quantification in the type of a term:
        forall a -> a -> a
      (GHC does not yet support this)
```

VDQ

- Fills in a gaping hole in GHC's kind language
- An important step towards dependent types in Haskell
- Amaze your friends, impress your coworkers, wow!

Debuts in GHC 8.10!