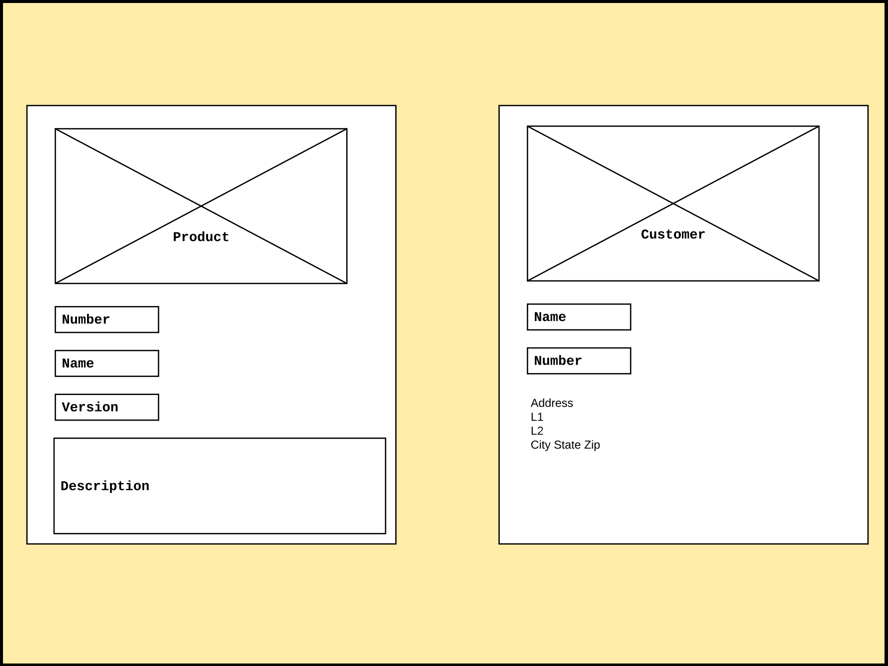
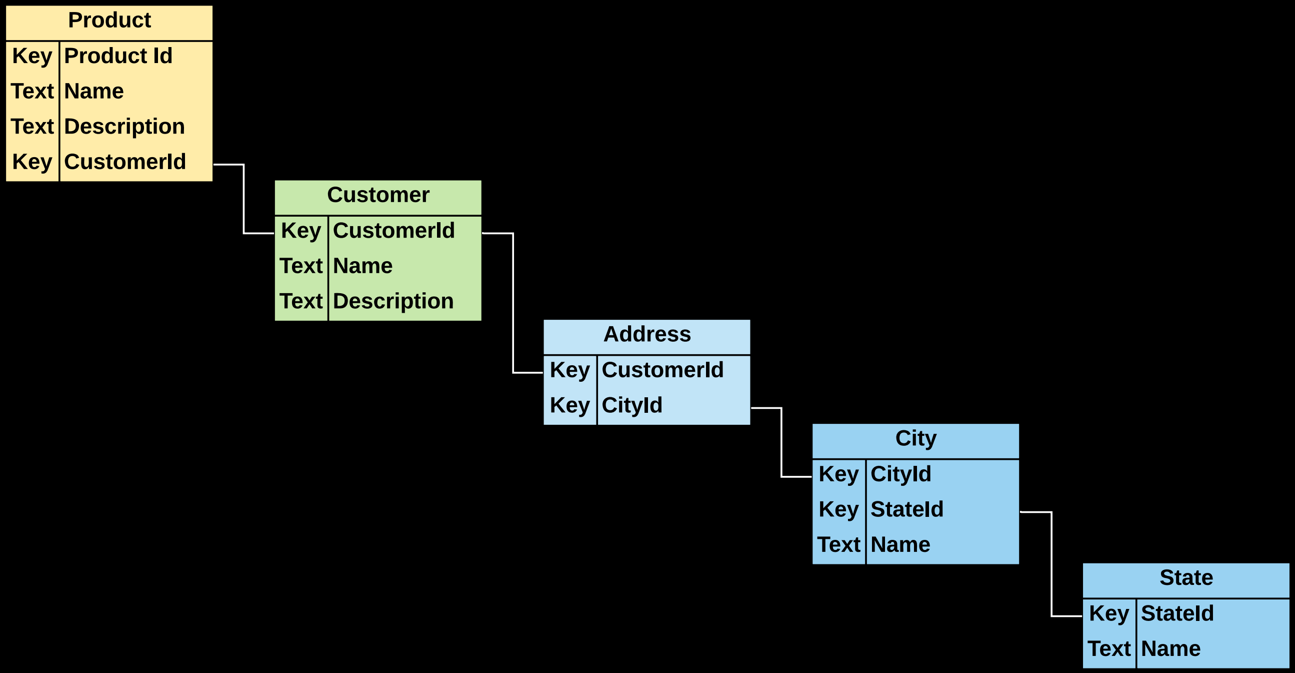
Data in Document View



Normalized Data for DB



Product	
Key	Product Id
Text	Name
Text	Description
Key	CustomerId

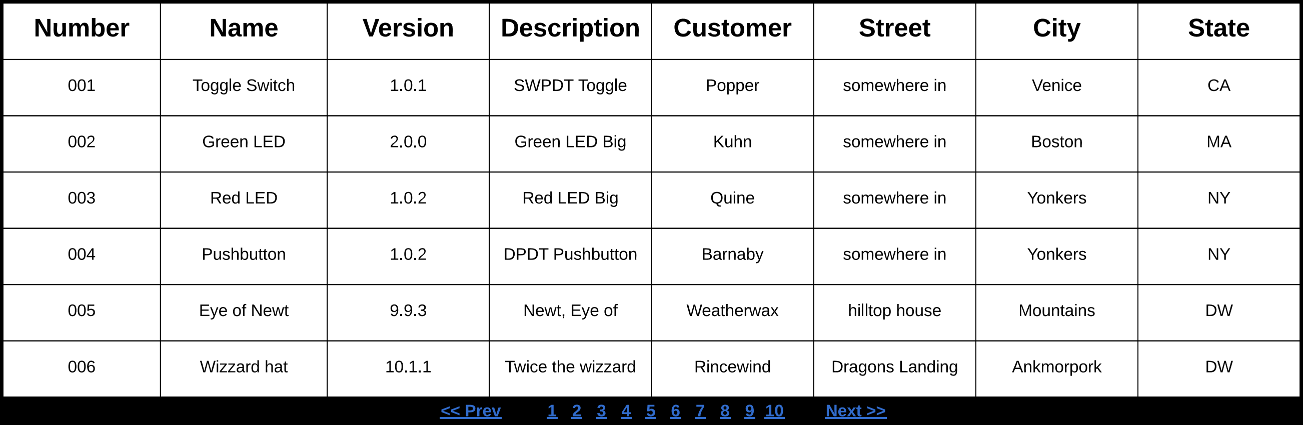
Customer	
Key	CustomerId
Text	Name
Text	Description

Address	
Key	CustomerId
Key	CityId

City	
Key	CityId
Key	StateId
Text	Name

State	
Key	StateId
Text	Name

Normalized Data for DB



Number	Name	Version	Description	Customer	Street	City	State
001	Toggle Switch	1.0.1	SWPDT Toggle	Popper	somewhere in	Venice	CA
002	Green LED	2.0.0	Green LED Big	Kuhn	somewhere in	Boston	MA
003	Red LED	1.0.2	Red LED Big	Quine	somewhere in	Yonkers	NY
004	Pushbutton	1.0.2	DPDT Pushbutton	Barnaby	somewhere in	Yonkers	NY
005	Eye of Newt	9.9.3	Newt, Eye of	Weatherwax	hilltop house	Mountains	DW
006	Wizzard hat	10.1.1	Twice the wizzard	Rincewind	Dragons Landing	Ankmorpork	DW

Properties!

And their relation to Types and Tests

Properties!

And their relation to Types and Tests

Or at least how to write programs that break a bit less.

Two ways of looking at properties

- The things that define an object.

```haskell
-- | Product numbers  are: [[:alnum:]]
-- unicode enc
-- Max length 140
-- Min length 1 (can't be empty)
newtype ProductNumber = ProductNumber { _unProductNumber :: Text}
  deriving (Show,Eq,Ord)
```

- The things that define what an object can do.

```haskell
-- Product numbers  uniquely determine a particular product
-- They can be sorted and compared
newtype ProductNumber = ProductNumber { _unProductNumber :: Text}
  deriving (Show,Eq,Ord)
```

- We will mostly be talking about the first.

The Haskell Toolbox

The skills to pay the bills.

- Type Encoding
- Smart Constructors
- QuickCheck
- Typed Transformation
- LiquidTypes

The Pattern.

The gist of what is going on...

- At the boundaries, use smart constructors and quick check to make sure types are built correctly.
- Use Type Encoding, Type Transformation, QuickCheck, and immutability to add or change data without having to recondition it.

Type Level Encoding

Put it where you can find it...

Create types to exactly match some set of properties.

e.g. ...

```
newtype  FixedText (lengthMax :: Nat)    -- Max text length
                   (lengthMin :: Nat)    -- Min text length
                   (regex     :: Symbol) -- What characters are allowable
              = FixedText { _unMyText :: Text}
  deriving (Show,Ord,Eq)
```

Correct By Construction!

```
--  Guarantees FixedText will have constrained length
  --  and valid characters.
fixedTextFromString :: forall max min regex .
  ( KnownNat    max
  , KnownNat    min
  , KnownSymbol regex) =>
    String ->
    Either FixedTextErrors (FixedText max min regex)

fixedTextFromString str = final
  where
    max'          = fromIntegral $ natVal (Proxy :: Proxy max)
    min'          = fromIntegral $ natVal (Proxy :: Proxy min)
    isTooLittle   = length str < min'
    regexStr      = symbolVal (Proxy :: Proxy regex)
    trimmedString = take max' str
    notRegex      = notValidRegex regexStr trimmedString
    final
      | isTooLittle = Left   FixedTextErrorMin
      | notRegex    = Left   (FixedTextErrorRegex regexStr trimmedString)
      | otherwise   = Right . FixedText .   pack $ trimmedString
```

Examples!

```
--  Just works, example
exampleFixedText  :: Either FixedTextErrors (FixedText 30 1 "[[:alnum:]]")
exampleFixedText = fixedTextFromString "exampleText1234"

$> exampleFixedText
Right (FixedText {_unFixedText = "exampleText1234"})


--  Cut off too much input.
exampleOverFlowProtection :: Either FixedTextErrors (FixedText 10 1 "[[:alnum:]]")
exampleOverFlowProtection = fixedTextFromString "exampleText1234"

$> exampleOverFlowProtection
Right (FixedText {_unFixedText = "exampleTex"})


--  Reject if invalid char
exampleInvalidChar :: Either FixedTextErrors (FixedText 30 1 "[[:digit:]]")
exampleInvalidChar = fixedTextFromString "exampleNotAllDigits"

$> exampleInvalidChar
Left (FixedTextErrorRegex "[[:digit:]]" "exampleNotAllDigits")
```

Make Mine a Monoid

```
--   Monoid instance with 0 minimum.
--   No FixedText besides one that has a minimum size of zero
--   should be a Monoid.
instance (KnownNat max, KnownSymbol regex) =>
 Monoid (FixedText (max::Nat) (0::Nat) (regex::Symbol)) where
  mempty  = FixedText ""
  mappend s1@(FixedText str1) (FixedText str2) =
      either (const s1)
             id
             (fixedTextFromText (str1 <> str2))
```

Arbitrary, but really specific

```
-- Arbitrary instance
-- This arbitrary instance takes advantage of
-- the Monoid defined above
instance ( KnownNat     max
         , KnownSymbol  regex) =>
  Arbitrary (FixedText max 0 regex) where

    arbitrary = let regexStr        = symbolVal (Proxy :: Proxy regex)
                    generatedString = Genex.genexPure [regexStr]

                 in either (const mempty) id <$>
                            QuickCheck.elements
                              (fixedTextFromString <$>
                                         generatedString)
```

Finally, a Property Test!

```haskell
qcProps :: TestTree
qcProps = testGroup "FixedText properties"
  [ QC.testProperty "((mempty <> str) == str)"                           leftIdMonoid
  , QC.testProperty "((str <> mempty) == str)"                           rightIdMonoid
  , QC.testProperty "(strA <>  strB) <> strC == strA <> (strB  <> strC)" associativityMonoid
  ]


type ExampleFixedText = FixedText 10 0 "[[01233456789]{0,3}"
leftIdMonoid  :: ExampleFixedText  -> Bool
leftIdMonoid str = ((mempty <> str) == str)

rightIdMonoid  :: ExampleFixedText  -> Bool
rightIdMonoid str = ((str <> mempty) == str)

associativityMonoid :: ExampleFixedText  ->
                       ExampleFixedText  ->
                       ExampleFixedText  -> Bool
associativityMonoid strA strB strC = leftAsc == rightAsc
  where
    leftAsc  = (strA <>  strB) <> strC
    rightAsc =  strA <> (strB  <> strC)
```

And the Results...

```
Progress: 1/2Tests
  Properties
    FixedText properties
      ((mempty <> str) == str):                           OK
        +++ OK, passed 100 tests.
      ((str <> mempty) == str):                           OK
        +++ OK, passed 100 tests.
      (strA <>  strB) <> strC == strA <> (strB  <> strC): OK (0.01s)
        +++ OK, passed 100 tests.
```

Victory!

Our Product Record

```haskell
data Product = Product {
 productNumber       :: ProductNumber,
 productName         :: ProductName,
 version             :: ProductVersion ,
 productCustomer     :: Customer,
 productDescription  :: TText }
    deriving (Eq,Ord,Show,Generic)

data Customer = Customer {
   customerName    :: CustomerName    ,
   customerNumber  :: CustomerNumber  ,
   customerAddress :: CustomerAddress }
    deriving (Eq,Ord,Show,Generic)

data CustomerAddress = CustomerAddress {
  street :: TText,
  city   :: TText,
  state  :: State}
    deriving (Eq,Ord,Show,Generic)

data State = Oklahoma | Texas | Kansas
    deriving (Eq,Ord,Show,Generic)
```

```haskell
-- | Base fields
newtype ProductNumber  = ProductNumber
  { unProductNumber  :: TText}
    deriving (Eq,Ord,Show,Generic)

newtype ProductName    = ProductName
  { unProductName    :: TText}
    deriving (Eq,Ord,Show,Generic)

newtype ProductVersion = ProductVersion
  {unProductVersion  :: TText}
    deriving (Eq,Ord,Show,Generic)
newtype CustomerName   = CustomerName
  { unCustomerName   :: TText}
    deriving (Eq,Ord,Show,Generic)
newtype CustomerNumber = CustomerNumber
  { unCustomerNumber :: TText}
    deriving (Eq,Ord,Show,Generic)

-- 140 characters alphanumeric unicode
type TText = FixedText 140 0 "[[:alnum:]]"
```

Separate Types Combined

Use the types to construct a document.

```
data ProductDocument = ProductDocument !Product !Customer !CustomerAddress
 deriving(Eq,Ord,Show,Generic)
```

Product as a Row

```
data ProductRow = ProductRow
  { rowProductNumber  :: ProductNumber,
    rowName           :: ProductName,
    rowVersion        :: ProductVersion,
    rowDescription    :: TText,
    rowCustomerName   :: CustomerName,
    rowCustomerNumber :: CustomerNumber,
    rowCustomerStreet :: TText,
    rowCustomerCity   :: TText,
    rowCustomerState  :: State }
   deriving(Eq,Ord,Show,Generic)
```

Isomorphism

```
toProductRow  :: Product -> ProductRow
toProductRow Product {..} = ProductRow productNumber productName    version productDescription
                                       customerName  customerNumber street  city                state
  where
    Customer {..}        = productCustomer
    CustomerAddress {..} = customerAddress


fromProductRow :: ProductRow -> Product
fromProductRow (ProductRow {..}) = Product rowProductNumber rowName rowVersion customer rowDescription
  where
    customer        = Customer        rowCustomerName   rowCustomerNumber customerAddress
    customerAddress = CustomerAddress rowCustomerStreet rowCustomerCity   rowCustomerState
```

Arbitrary Generation

```
instance Arbitrary ProductVersion where
    arbitrary = genericArbitrary

    instance Arbitrary ProductNumber where
    arbitrary = genericArbitrary

    instance Arbitrary ProductName where
    arbitrary = genericArbitrary

    instance Arbitrary Product where
    arbitrary = genericArbitrary

    instance Arbitrary CustomerName where
    arbitrary = genericArbitrary

    ...
```

Most Code is Mutable

```
rowDocumentIsoTest :: Product -> Bool
    rowDocumentIsoTest prod = ((== prod) .
                               fromProductRow .
                               toProductRow    )  prod
```

```
Product Properties
      round-trip test Product:                            OK
        +++ OK, passed 100 tests.
```

Can we do better?

- Proofs not Tests!
- A way to deal with more at the type level.

```
{-@ measure notEmpty @-}

    notEmpty [] = False
    notEmpty _  = True

    {-@ type NotEmptyList a = {xs:[a] | notEmpty xs } @-}
    {-@ headSafe :: NotEmptyList a -> a @-}

    headSafe (x:xs) = x

    tryToUseHeadSafeUnSafely = headSafe []
```