

Semantic Design

The following is what I call a 'semantic design' for Nu's scripting system (as well as an unrelated replacement for micro-services called MetaFunctions). The concept of a semantic design is inspired by Conal Elliot's denotational design - <https://www.youtube.com/watch?v=bmKYiUOEo2A>.

To specify semantic designs generally, I've created a meta-language called SEDELA (for Semantic Design Language). First, we present the definition of SEDELA, then the semantic design for Nu's scripting system as well MetaFunctions in terms of SEDELA. Although I may aim to write a parser and type-checker for SEDELA, there will never be a compiler or interpreter. Thus, SEDELA will have no syntax for **if** expressions and the like. The only Meanings (SEDELA's nomenclature for functions) defined in the Prelude will be combinators such as `id`, `const`, `flip`, and etc. SEDELA's primitive types are all defined in terms of Axioms (types without formal definitions) with no available operations.

Sedela Language Definition

Axiom :=	Axiom[!] "Informal definition."	where ! denotes intended effectfulness
Meaning Type :=	A -> ... -> Z	where A ... Z are Type Expressions
Meaning Defn :=	f (a : A) ... (z : Z) : R = Expression Axiom	where f is the Meaning Identifier and a ... z are Parameter Identifiers and A ... Z, R are Type Expressions
Expression :=	Example: f a (g b)	where f and g are a Meaning Identifiers and a and b are Paremeter Identifiers
Product :=	MyProduct<...> = A (A : A, ..., Z : Z) Axiom	where MyProduct<...> is the Product Identifier and A ... Z are Field Identifiers and A ... Z are Type Expressions
Sum :=	MySum<...> = A of (A Axiom) ... Z of (Z Axiom)	where MySum<...> is the Sum Identifier and A ... Z are Case Identifiers and A ... Z are Type Expressions
Type Identifier :=	Product Identifier Sum Identifier	
Type Expression :=	Meaning Type Type Identifier	
Type Parameters :=	Type Identifier < A, ..., Z; A<A, ..., Z>; ...; Z<...>>	where A ... Z are Type Expressions and A ... Z are Category Identifiers used for constraining A ... Z
Category :=	category MyCat<...> = f : A ... g : Z	where MyCat<...> is the Category Identifier and f ... g are Equivilence Identifiers and A ... Z are Types Expressions
Witness :=	witness A = f (a : A) ... (z : Z) : R = Expression ... g (a : A) ... (z : Z) : R = Expression	where A is a Category Identifier and f ... g are Equivilence Identifiers and a ... z are Parameter Identifiers and A ... Z, R are Type Expressions
Categorization :=	Rule: iff type A has a witness for category A, A is allowable for type parameter categorized as A	

Line Comment :=	Example: // comment text
<code>fun a b ... z -> expr :=</code>	<code>\a (\b (... \z.expr))</code>
<code>a -> b :=</code>	<code>_ = (_ : a) : b</code>
<code>() :=</code>	Explanation: The unit type / value.
<code>f . g :=</code>	Explanation: Function composition.

Sedela Language Prelude

```
Any = Axiom "The universal base type."
Bool = Axiom "A binary type."
Real = Axiom "A real number type."
Whole = Axiom "A whole number type."
String = Axiom "A textual type."
Maybe<a> = | Some of a | None
Either<a, b> = | Left of a | Right of b
List<a> = | Nil | Link of (a, List<a>)
Map<a, b> = | Leaf of (a, b) | Node of (Map<a, b>, Map<a, b>)
```

```
category Semigroup<a> =
  | append : a -> a -> a
```

```
category Monoid<m; Semigroup<m>> =
  | empty : m
```

```
category Functor<f> =
  | map<a, b> : (a -> b) -> f<a> -> f<b>
```

```
category Pointed<p; Functor<p>> =
  | pure<a> : a -> p<a>
```

```
category Applicative<p; Pointed<p>> =
  | apply<a, b> : p<a -> b> -> p<a> -> p<b>
```

```
category Alternative<l; Applicative<l>> =
  | empty<a> : l<a>
  | choice : l<a> -> l<a> -> l<a>
```

```
category Monad<m; Applicative<m>> =
  | bind<a, b> : m<a> -> (a -> m<b>) -> m<b>
```

```
category Comonad<c; Functor<c>> =
  | extract<a> : c<a> -> a
  | duplicate<a, b> : c<a> -> c<c<a>>
  | extend<a, b> : (c<a> -> b) -> c<a> -> c<b>
```

```
category Foldable<f> =
  | fold<a, b> : (a -> b -> b) -> b -> f<a> -> b
```

```
category Traversable<t; Functor<t>; Foldable<t>> =  
  | traverse<a, b, p; Applicative<f>> : (a -> p<b>) -> t<a> -> p<t<b>>
```

```
// TODO: define the Arrow categories.
```

```
id a = a  
const a _ = a  
flip f a b = f b a
```

Nu Script Semantic Design

```
witness Monoid =  
  | append = +  
  | empty = toEmpty -t-
```

```
witness Monad =  
  | map = map  
  | pure = toPure -t-  
  | apply = app  
  | bind = bind
```

```
witness Foldable =  
  | fold = fold
```

Property = Axiom "A property of a simulant."

Relation = Axiom "Indexes a simulant or event relative to the local simulant."

Address = Axiom "Indexes a global simulant or event."

get<a> : Property -> Relation -> a = Axiom "Retrieve a property of a simulant indexed by Relation."

set<a> : Property -> Relation -> a -> a = Axiom! "Update a property of a simulant indexed by Relation, then returns its value."

Stream<a> = Axiom "A stream of simulant property or event values."

getAsStream<a> : Property -> Relation -> Stream<a> = Axiom "Construct a stream of values from a simulant property."

setToStream<a> property relation stream = foldStream (fun _ -> set<a> property relation) stream

eventStream<a> : Address -> Stream<a> = Axiom "Construct a stream of values from event data."

foldStream<a, b> : (b -> a -> b) -> Stream<a> -> b = Axiom "Fold over a stream."

productStream<a, b> : Stream<a> -> Stream -> Stream<(a, b)> = Axiom "Combines two streams into a single product stream"

sumStream<a, b> : Stream<a> -> Stream -> Stream<Either<a, b>> = Axiom "Combines two streams into a single sum stream."

mapStream<a, b> mapper stream = foldStream (fun _ -> mapper a) stream

```
witness Comonad =  
  | map = mapStream  
  | extract = fun f a -> f a  
  | duplicate = fun f -> f f  
  | extend = fun f -> map f . duplicate
```

Semantic Design for MetaFunctions (a replacement for micro-services - unrelated to Nu)

```
Symbol =
  | Atom of String
  | Number of String
  | String of String
  | Quote of Symbol
  | Symbols of List<Symbol>
symbolToString (symbol : Symbol) : String = Axiom "Convert a symbol to string."
symbolFromString (str : String) : Symbol = Axiom "Convert a string to a symbol."

Vsync<a> = Axiom "The potentially asynchronous monad such as the one defined by Prime."
vsyncBind<a, b> (vsync : Vsync<a>) (f : a -> Vsync<b>) : Vsync<b> = Axiom "Create a potentially asynchronous operation."
vsyncReturn<a> (a : a) : Vsync<a> = Axiom "Create a potentially asynchronous operation that return the result 'a'."
witness Monad =
  | bind = vsyncBind
  | return = vsyncReturn

IPAddress = String
NetworkPort = Whole
Endpoint = (IPAddress, NetworkPort)
Intent = String // the intended meaning of a MetaFunction (indexes a MetaFunction from a Provider - see below)

Container = Intent -> Symbol -> Vsync<Symbol>
Provider = | Endpoint | Container
MetaFunction = Provider -> Intent -> Symbol -> Vsync<Symbol>

makeContainer (asynchrinous : Bool) (repositoryUrl : String) (credentials : (String, String)) (envDeps : Map<String, Any>) :
Container = Axiom "Make a container configured with its Vsync as asynchrinous or not, built from source pulled from the givern
GIT url, and provided the given environmental dependencies."

attachDebugger (container : Container) = Axiom! "Attach debugger to code called inside the given container."

call (mfn : MetaFunction) provider intent args : Vsync<Symbol> = mfn provider intent args
```