

## 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

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

<b>Line Comment</b> :=	<b>Example:</b> // comment text
fun a b ... z -> expr :=	\a (\b (... \z.expr))
a -> b :=	_ = (_ : a) : b
() :=	<b>Explanation:</b> The unit type / value.
f . g :=	<b>Explanation:</b> 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 Applicative<p; Functor<p>> =  
  | pure<a> : a -> p<a>  
  | 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>  
  | return<a> : a
```

```
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> =  
  | foldMap<m; Monoid<m>> : (a -> m) -> f<a> -> m
```

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

```
witness Foldable =  
  | foldMap = foldMap
```

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

sumStream<a, b> : Stream<a> -> Stream<b> -> 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
```