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 intepreter. Thus, SEDELA will have no syntax for **if** expressions or 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 | Axiom
  | ...
  | g (a : A) ... (z : Z) : R = Expression | Axiom
```
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
fun *a b* ... *z* -> *expr* **:=**	*a* (*b* (... *z*.*expr*))
a **->** *b* **:=**	_ = (_ : *a*) : *b*
() :=	**Explanation:** The unit type / value.
f . g :=	**Explanation:** Function composition.

Sedela Language Prelude

```
Bool = Axiom "A binary type."
Whole = Axiom "A whole number type."
Real = Axiom "A real number type."
String = Axiom "A textual type."
Maybe<a> = | Some of a | None
Either<a, b> = | Left of a | Right of b

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

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


category Monad<m> =
  | bind<a, b> : m<a> -> (a -> m<b>) -> m<b>
  | return<a> : a


category MonadPlus<m; Monoid<m>; Monad<m>>


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

id a = a

const a _ = a

flip f a b = f b a
```

Nu Semantic Design

```
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)

```
Any = Axiom "The base type of all types."
List<a> = Axiom "The functional list type such as the one defined by F#."
Map<a, b> = Axiom "The functional map type such as the one defined by F#."
Vsync<a> = Axiom "The potentially asynchronous monad such as the one defined by Prime."
Symbol = Axiom "Symbolic type such as the one defined by Prime."

IPAddress = String // a network address
Port = Whole // a network port
Endpoint = (IPAddress, Port)
Intent = String // the intended meaning of a MetaFunction (indexes functionality from a provider)

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

makeContainer (asynchrounous : Bool) (repositoryUrl : String) (credentials : (String, String)) (envDeps : Map<String, Any>) :
Container = Axiom "Make a container configured with its Vsync as asyncronous 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
```