Ensō

William R. Cook and Tijs van der Storm

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Ensō is a theoretically sound and practical reformulation of the concepts of model-driven software development. Ensō is based on first-class *structural descriptions*, bi-directional *transformations*, *generic operations* and *interpretation*.

Structures in Ensō are a specialized kind of graph, whose nodes are either primitive values or collections of observable properties, whose values are either nodes or collections of nodes. From a programming language viewpoint this may seem an odd choice for data representation. However, it is essentially the Entity-Relationship (ER) model [**?**], also known as Information Models [**?**], which is widely used in the design of relational databases and is also the basis for Class Diagrams in the Unified Modeling Language (UML) [**?**], which describe the structure of networks of objects. The key point is that structures in Ensō are viewed holistically as *graphs*, not as individual values or traditional sums-and-products data structures.

A structural description, or *schema*, specifies some of the observable properties of structures. Schemas are used to check the consistency structures. Some properties can be checked while the structure is being created, but other can only be checked once the structure is complete. Ensō allows modification of structures, which is necessary to create cyclic graphs, but also allows valid structures to be sealed to prevent further changes.

Bi-directional transformations are used to map one structure into another kind of structure, such that mapping can be inverted to (partially) recover the original structure from the result. One common kind of transformation is called a *grammar*, which is a bi-directional transformation between structures and text. Text grammars are bi-directional because they can be used for parsing and also rendering. Other transformations include Diagram grammars, which map structures into diagrams, were edits on the diagram are reflected in the original structure. GUI grammars are similar. Transformations are also used for querying, template processing, and serialization.

Ensō is based on interpretation rather than code generation. While it is possible to define transformations that generate code in conventional languages, this is rarely (if ever) done in Ensō. Instead all structural descriptions and transformations are interpreted dynamically. Although the current incarnation of Ensō does not include it, we have previously demonstrated that partial evaluation can be applied to Ensō-style interpreters to automatically generate efficient code.

Modularity, generic operations, change management, dynamic creation of schemas and transformations. Schemas and transformations are also structures.

What follows is a rapid introduction to the concepts and use of Ensō. To avoid too many digressions, the many connections between Ensō and existing approaches, including programming models (model-driven, object-oriented, polytypic, functional, constraint-based), theory (dependent types, coalgebra, category theory), and related ideas (relational databases, domain-specific languages) are discussed in Section 0.3.

0.1 Data

Ensō represents all data via graphs whose structure is defined by a form of entity-relationship model, called a *schema*. Ensō shifts focus away from individual pieces of data, to focus instead on semantically integrated collections of data.

An Ensō data structure is analogous to an information model, a relational database, an object model without methods, or a coalgebra. While it is easy to create specialized data modeling notations in Ensō, the standard information model has the following properties:

Structure are created by *factories*, which create and manage the nodes in the structure. The factory also ensures that structures are distinct: a factory identifies the collection of nodes that belong to a graph, and any given node can only be connected to other nodes in the same graph, which were created by the same factory.

In Ensō most properties of a structure are checked when the structure is being created. In other words, the *factory* that creates the structure is parameterized by a schema, which the factory uses to check the legality of operations on the objects it creates.

0.2 Presentation

as cyclic graphs, where nodes are categories into types that have consistent attributes and edges are labeled.

All data is represented as cyclic graphs of

"information model": "relational database": the nodes of the graph are rows of the tables. Foreign keys

Data is represented as

This example converts schemas into constructor grammars

```
grammar NAME:sym
   CLASSES:
     rule NAME:sym =
        (SUBTYPES: { NAME:sym "|") "|" @"!SUBTYPES.empty?")?
```

```
[NAME:sym] NAME:str "{"
   FIELDS: { (NAME:str ":" (NAME:sym): (
        "[" { TYPE.NAME:sym^ "," } "]"   @"MANY=true"
      | TYPE.NAME:sym^ ?                  @"OPTIONAL=true"
      | TYPE.NAME:sym^
      )) ";" }
    "}"
```

0.3 Relationship to Other Approaches

Ensō data is based on traditional entity-relationship (ER) models [?], which are also known as information models. ER models were the basis for class diagrams in UML.

In contrast to object-oriented programming, Ensō is focused on holistic object graphs, rather than individual objects. Ensō does allow data to include some behavior, for example constraints and computed fields, but Ensō does not associated methods with data objects.

In contrast to most theories of functional programming, Ensō is based on coalgebraic signatures rather than algebraic ones. In practice this means that Ensō structures are cyclic graphs rather than trees. Lazy functional languages can also represent cyclic structures, but the cycles are not observable.

Ensō supports controlled imperative effects. Objects are mutable during construction or modification, while the data may be in an inconstent state, but before it can be used it must be validated and locked from further changes. This is similar to a transaction.

1 Requirements for a programming language

The programming model is based on cyclic graphs. Graphs are kept distinct from each other. That is, each graph is considered a self-contained artifact, without links or pointers to other graphs.

A natural way to create such graphs is with imperative effects.

This potentially requires more copying of data than would be the case in tree-based representations.

To modify graphs, place-holder objects are useful, as is the ability to "become" another object.

1.1 Simple reflection

Fields can be created dynamically and accessed with "." notation or reflective access.

```
o.foo   == o.get("foo")
```

Assignment to fields can be overriden

```
o.bar = 3   ==> o.set("bar", 3)
```

2 QuadModel

3 Todos

* merging schemas and grammars. Need a merge operation. Based on identification/unification

* Finalize on objects, that checks required fields, seals from changes, run invariants

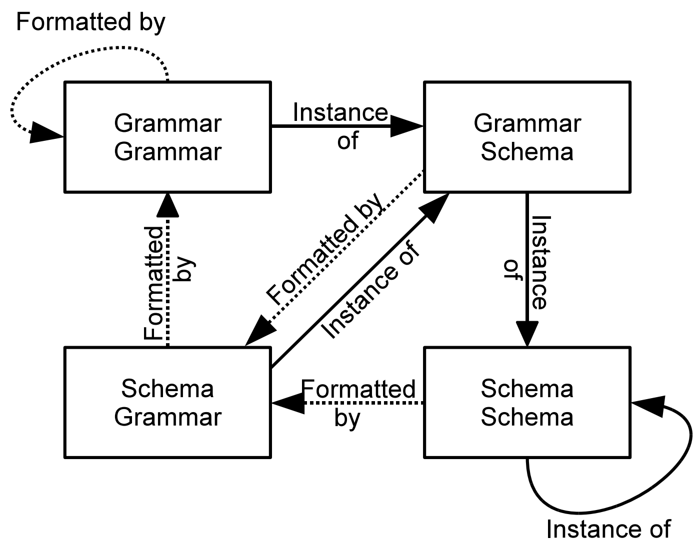
* removing "key" from grammar

* fix pretty printing

* GUIs

* fixedpoint cyclic map

* checked model-objects (with correct inverses and type checking) * derivative parsers? * other kind of parser? * executable UML? * graphical editors? (does Ruby have graphics binding?) * database mapping? * WebDSL mini-language



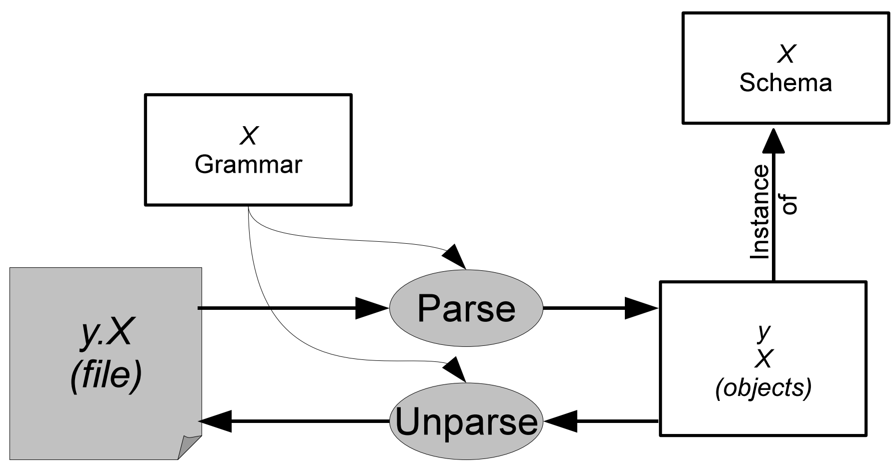


Figure 1: **default**