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Lightweight Typed Customizable Unmarshaling

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1. Abstract
The contribution of this work is threefold. First, we offer an OCaml
unmarshaling algorithm that uses a lightweight type-directed de-
scription of the expected structure of data to make consistency
checks. The second contribution is the opportunity to specify func-
tions to be systematically applied on values as they are being un-
marshaled. Our third contribution is a type-safe layer for these
functions and for the unmarshaling algorithm itself.

2. Description
The standard OCaml unmarshaling function is input_value:
in_channel → α. The aforementioned first contribution is a
function descr_input_val with type in_channel → descr → α. One value of type descr that can be passed as second argu-
ment is Abstract, and then the behavior is exactly identical to
input_value. The programmer can provide as much information as (s)he wants for the additional consistency checks. For instance, (s)he can pass the value (τ_array Abstract) to specify that the
value being read is an array of undescribed values. Our unmar-
shaling algorithm maintains a cursor into the structure description,
allowing it to know what the current loaded value should look like.

A value of type descr can include functions to be applied on
the values as they are built. This is necessary for instance when
unmarshaling values of hashconsed types: the maximal sharing
invariant must be preserved[CD08]. In this case the programmer
may use a description containing a function f of type τ → τ
to rehash these values. In order to allow this, our unmarshaling
function preserves OCaml’s runtime invariants, including for the
partially reconstructed values. The historical implementation of
marshaling in OCaml is written in C and does not have this property.
The new unmarshal is written in low-level unsafe OCaml. It is
compatible with the existing format, so that it can be used with the
old marshal function.

Unfortunately, it is not possible to type the function f above
in a safe way. The low-level API requires it to have type Obj.t
→ Obj.t. The programmer must use unsafe coercions to imple-
ment it. We lessen this drawback with a type-safe layer that re-
lies on a dynamic representation of OCaml types[Sig11b, Sig11a].
The type descr of descriptors becomes a polymorphic phantom
type in which the type variable encodes the static type being de-
scribed. The type expected for function f above becomes α descr
→ α → α. Thus f can be written without unsafe operations, by
providing an extra argument corresponding to the type of the un-
marshaled value. Additionally, we also offer a typed unmarshal-
ing function typed_input_val: in_channel → α descr → α which constrains the unmarshaled value to be used in a context
compatible with the type of the descriptor.

3. Assessment and Availability
The described work has been implemented and has been used for
loading analysis projects[Sig09] inside Frama-C[CS09]. The low-
level layer was provided in Frama-C version Boron, and the type-
safe layer was made available with version Carbon.

A previous implementation used the standard OCaml unmar-
shaling function. Disadvantages were numerous: the re-hashing of
hashconsed values had to be done in a second pass after unmar-
shaling. Just before this second pass was done, two versions of the
loaded project would exist in memory, causing a peak in memory
use. It was necessary to remember which subvalues had already
been visited, and the corresponding re-hashed versions. Otherwise,
rehashing would produce the expected results but would take a very
long time to do so, visiting the highly shared DAG representing the
analysis project as if it were a tree.

All these problems are solved by the new unmarshaling func-
tion. The re-hashing is done value per value as they are created,
and the non-shared value that came from disk can be forgotten im-
nediately, streamlining memory usage. A table mapping node ids
to corresponding re-hashed values exists during unmarshaling with
the new implementation. However, this table is maintained by the
unarshal function, and the programmer does not need to know
about it. By contrast, with the previous implementation, the pro-
grammer had to maintain such a table for every type, whether un-
marshaled or not. While it was possible to factor the implementa-
tion of this table a little, the fact that constructors are not first-class
value prevented true genericity.

4. Related Work
Kennedy [Ken04] describes a library of marshaling combinators
for Haskell. These combinators work at the language level without
any magic, but the programmer has to describe the data types in
full detail by combining the combinators. The marshaling format is
specific to this library. By contrast, our system uses OCaml’s low-
level marshaler and allows the programmer to give an incomplete
description of the type being unmarshaled. Kennedy’s work is
extended and adapted to Standard ML by Elsman in [Els05], which
introduces difficulties due to references and cyclic data structures.
In both cases, the programmer can use the wrap combinator to
get the same effect as our function f. Combinators are a lot more
verbose to use than our type descr.
Rossberg et al. [RTK07] describe a much more ambitious system: higher-order typed pickles in Alice ML, where they are an important component of the system. Unlike OCaml’s marshaled values, they carry type information. In this system, transform nodes can be used to get the effect of our f function.

The programming language Acute [SLW+05] and its extension HashCaml [BSSS06] provide safe (un)marshaling by marshaling a type representation ty computed by the compiler for each written value v and by comparing ty to the expected type at the time v is unmarshaled. This approach is based on a dedicated language which provides type representations at runtime. It also requires the marshaling of some additional data. Neither is required in our approach.

Henry [HMC07, Hen11] provides type-safe unmarshaling for OCaml without marshaling types by verifying the compatibility of the value being unmarshaled with the expected type. Its approach nevertheless modifies the OCaml compiler, while our approach is fully compatible with the standard OCaml compiler.

Neither Acute nor Henry’s proposal allow to apply custom functions at unmarshal time, which was our primary goal.

The ATerms library [BJKO00] (in C and Java) has both hashconsing and unmarshaling. Not having to be backwards compatible with an existing format, it marshals data bottom-up (the standard OCaml format, with which our function is compatible, is top-down). Bottom-up complicates marshaling a little, but simplifies unmarshaling a lot. Being untyped, in ATerms many types of data can be represented with a few, fixed kinds of nodes chosen in advance.

5. Conclusion

We have presented a solution to mix hashconsing and unmarshaling. This solution is implemented and, at the time of publishing, has been used for months inside the analysis framework Frama-C. We get the impression that the problems we had to solve have been discovered and solved many times over in different contexts, and we hope that, in the context of OCaml, the next person who needs something like this will find this implementation rather than going through the same issues again.

Acknowledgements

Norman Ramsey and Jurgen Vinju suggested many of the comparable, existing systems to look at. All core Frama-C developers had to suffer while unmarshaling and hashconsing issues were being understood and solved, but we would like to apologize in particular to Boris Yakobowski, who bore most of the brunt.

References