The Serialization Killer Language

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Abstract

This work presents an alternative to various serialization approaches. The proposed serialization mechanism is fast, robust, extensible and easy to use. These goals are achieved by not using a human readable serialized form. To do (1)

Acknowledgements

For productive criticism: Erhard Plödereder and Martin Wittiger To do (2)

To do (3)

To do (4)

1 Motivation

This paper presents an approach to serializing objects, which is tailored for usability, performance and portability. In order to achieve these goals, in contrast to XML, we will sacrifice generality and human readability of the serialized format. Unlike other general serialization mechanisms, we provide explicit support for extension points in the serialized data, in order to provide a minimum of upward compatibility and extensibility.

1.1 Related Work

There are many approaches similar to ours, but most of them have a different focus. This section shall provide a concise list of related approaches. For potential users of skill, this might also present alternatives superior for individual use cases.

The very nature of the problem requires different solutions, blablabla, skill is basically related to serialization like XML on one side and language interfaces like IDL or even JNI on the other side.

XML

XML is a file format and might in fact be used as a backend. If a human readable storage on disk is not required, a binary encoding can be used to improve load/store performance significantly. To do (5)

XML Schema definitions

The description language itself is more or less equivalent to most schema definition languages such as XML Schema . The downside is that schema definitions have to operate on XML and can not directly be used with a binary format. There is also no way to generate code for a client language, such as Ada, from schema definitions. To do (6)

JAXP and xmlbeansxx

For Java and C++, there are codegenerators, which can turn a XML schema file into code, which is able to deal with an xml in a similar way, as it is proposed by this work. In case of Java this is even in the standard library. The downside is, that, to our knowledge, this is only possible for Java and C++, thus it leaves us with portability issues. A minor problem of this approach is the lack of support for comment generation and the inefficient storage of serialized data. An interesting observation is, that this approach deprives xml of its flexibility advantage over our solution. To do (7)

ASN.1

Is not powerful enough to fit our purpose.

IDL

To do (8)

Is not powerful enough and seems to be outdated.

Apatche Thrift & Protobuf

Lacks subtypeing. Protobuf has a overly complex notation language. Both seem to be optimized for network protocols, thus they do not have storage pools, which are the foundation of our serialization approach and an absolute requirement for some of our features, such as hints (see section 6).

Language Specific

Language specific is language specific and can therefore not be used to interface between subsystems written different programming languages such as Ada, Java, C or Haskell. Plus not every language offers such a mechanism. E.g. C.

Language Interfaces

Language Interfaces do not permit serialization capabilities. Most language only provide interfaces for C, with varying quality and varying degree of automation. A significant problem are interfaces between languages with different memory models. Interfaces between languages with different type systems are simply unproductive:D

2 Syntax

We use the tokens `<id>`, `<string>`, `<int>` and `<comment>`. The represent C-style identifiers, strings, integer literals and comments respectively. Note that we use a comment token, which is need, because we want to emit the comments in the generated code, in order to integrate nicely into the target languages documenting system.

```
UNIT :=
  INCLUDE*
  DECLARATION*

INCLUDE :=
  ("include"|"with") <string> ";"?

DECLARATION :=
  DESCRIPTION
  <id>
  ((":"|"with"|"extends") <id>)?
  "{" FIELD* "}"

FIELD :=
  DESCRIPTION
  (CONSTANT|DATA) ";"?

DESCRIPTION :=
  (RESTRICTION|HINT)*
  <comment>?
  (RESTRICTION|HINT)*

RESTRICTION :=
  "@" <id> ("(" (R_ARG ("," R_ARG)*)? ")")?

R_ARG := ("%"| <int>)

HINT := "!" <id>

CONSTANT :=
  "const" TYPE <id> "=" <int>

DATA :=
  "auto"? TYPE <id>

TYPE :=
  ("map" MAPTYPE
  |"set" SETTYPE
  |"list" LISTTYPE
  |ARRAYTYPE)

MAPTYPE :=
  "<" GROUNDTYPE ("," GROUNDTYPE)+ ">"

SETTYPE :=
  "<" GROUNDTYPE ">"

LISTTYPE :=
  "<" GROUNDTYPE ">"

ARRAYTYPE :=
  GROUNDTYPE
  ("[" (<id>|<int>)? "]")?

GROUNDTYPE :=
  (<id>|"annotation")
```

Note: The Grammar is LL(1).

Comment: The optional ; at the end of includes or definitions are for convenience only.

Comment: There will eventually be a mechanism to add functional specifications, such as range restrictions, to fields, which is expected to use @ and ;.

2.1 Reserved Words

The language itself has only the reserved words **annotation**, **auto**, **const**, **indexed**, **tagged**, **with**, **map**, **list** and **set**.

However, it is strongly advised against using any identifiers which form reserved words in a potential target language, such as Ada, C++, C#, Java, JavaScript or Python.

To do (9)

2.2 Examples

Nice example

To do (10)

Listing 1: Running Example

```
/** A source code location. */
SLoc {
  i16 line;
  i16 column;
  string path;
}

tagged Block {
  SLoc begin;
  SLoc end;
  string image;
}

tagged IfBlock with Block {
  Block thenBlock;
}

tagged ITEBlock with IfBlock {
  Block elseBlock;
}
```

Includes, self references

Listing 2: Example 2a

```
with ”example2b.skill”
```

```
indexed A {
  A a;
  B b;
}
```

Listing 3: Example 2b

```
with "example2a.skill"

B {
  A a;
}
```

Unicode

The usage of non ASCII characters is completely legal, but might cause severe portability issues.

Listing 4: Unicode Support

```
/** some arguably legal unicode characters. */
ö {
  ö ß;
  ö €;
}
```

2.3 On ADTs

ADTs are represented using arrays and pairs.

ADTs showed to be useful and to increase the usability and understandability of the resulting code and file format.

3 Semantik

Bedeutung der einzelnen Schlüsselwörter

3.1 Includes

The file referenced by the with statement is processed as well. The declarations of all files reachable over `with` statements are collected, before any declaration is evaluated.

3.2 `tagged`

The type has a tag which allows it to be subtyped using single inheritence.

3.3 `annotation`

The type has a tag and a size, which allows it to be inserted at any annotation locations. This is useful in order to provide extension points in the file format. The file will still be readable by older implementations, which are not able to map any meaningful type into the annotation. Annotations may be subclassed by other annotations using single inheritence.

As we will see later, annotation can be seen as equivalent to the type

```
tagged annotation {
  v64 size;
}
```

with the constraint, that size is the size of the serialized form of the annotation in bytes.

3.4 Subtypeing

A subtype of a userdefined type can be declared by appending the keyword `with` and the supertypes name to a declaration. In order to be wellformed, the subtype must have exactly the type modifiers(i.e. indexed, tagged/annotation) of the supertype. This is because all subtypes of an indexed type will share a single storage pool.

3.5 `const`

A const field can be used in order to create guards or version numbers, as well as overwriting deprecated fields with e.g. zeroes. The deserialization mechanism has to report an error if a constant field has an unexpected value.

3.6 `auto`

The language binding will create a field with the given type, but the content is transparent to the serialization mechanism. This is useful if the inference of the content of a field is likely to be faster then storing it, e.g. if it can be inferred lazy.

3.7 Abstract Data Types

The type system has a built-in notion of arrays, maps, lists and sets. Note that all of them are, from the view of serialization, equivalent to length encodeded arrays. They are added just to make modeling easier. To do (11)

To do (12)

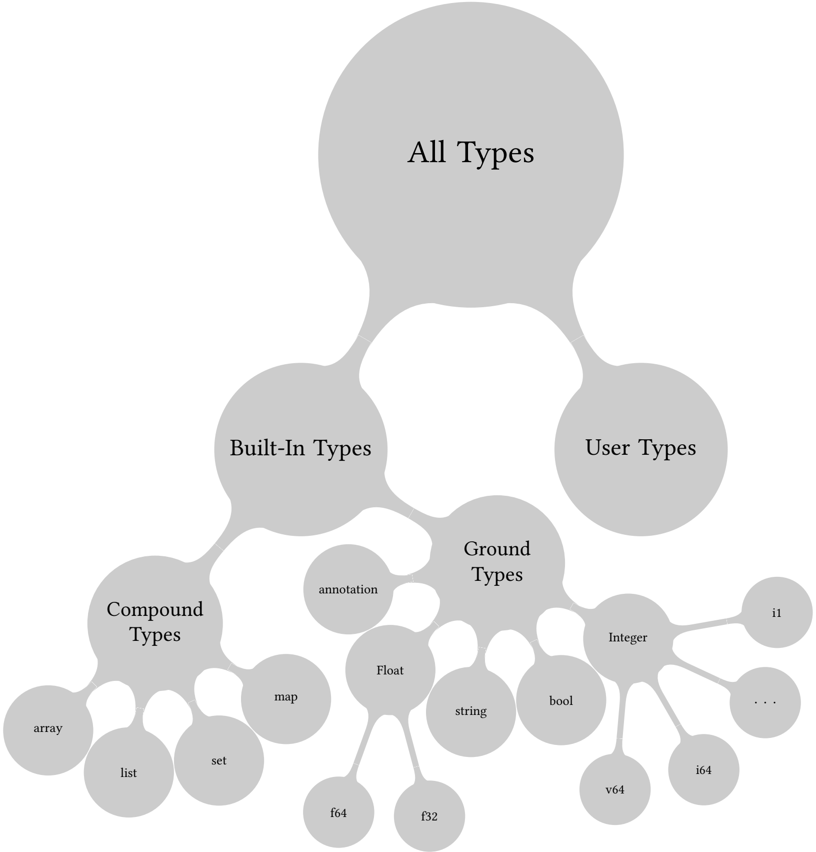
3.8 Comments

Comments provided in the skill file will be emitted into the generated code[1], thus allowing a user to profit from tooltips his IDE is likely to show him, containing this documentation. To do (13)

[1] If the target language does not allow for C-Style comments, the comments will be transformed in an appropriate way.

4 The Type System

The basic layout of the type system is:



User types can be seen as nonempty tuples over all types. It is legal to *rename* a ground type, in order to give it a special semantics. E.g. to create a time stamp by:

```
time {
  /** seconds since 1.1.1970 0:00 UTC. */
  i64 date;
}
```

Legal Types

This section is to define the set of types, which can be used to declare legal fields inside a user type definition. Let $\mathcal{T}$ be the set of all types, $\mathcal{B} \in \mathcal{T}$ be the set of built-in types, $\mathcal{G} \in \mathcal{B}$ be the set of ground types, $\mathcal{C} \in \mathcal{B}$ be the set of compound types and $\mathcal{I} \in \mathcal{G}$ be the set of integer types. Let $mod : \mathcal{T} \setminus \mathcal{G} \rightarrow 2^{\{indexed,tagged,annotation\}}$ be the set of modifiers for a given type t.

In this context, we talk about an unknown, but fixed set $\mathcal{T}$, which corresponds to the contents of a set of input files. We silently assume, that all types have unique names. Declaring a type with the name of another types is therefore considered an error.

Wellformed type declaretions:

- If $\mathtt{s} \in \mathcal{T} \setminus \mathcal{G}$, $mod(\mathtt{t}) = mod(\mathtt{s})$ and $annotation \in mod(\mathtt{t}) \rightarrow tagged \notin mod(\mathtt{t}) \wedge indexed \notin mod(\mathtt{t})$ then $mod(\mathtt{t})$`t with s{...}` is a wellformed type declaration and `t` is called a subtype of `s`.

- If $\mathtt{t} \in \mathcal{T} \setminus \mathcal{G}$ and $annotation \notin mod(\mathtt{t}) \vee tagged \notin mod(\mathtt{t})$ then $mod(\mathtt{t})$`t {...}` is a wellformed type declaration.

- The subtype relation is acyclic.

Let f be a field. The field is legal in one of the following cases:

- If $\mathtt{t} \in \mathcal{I}$ then `const t f` is a legal constant field.

- If $\mathtt{t} \in \mathcal{T} \setminus \mathcal{C}$ then `t f` is a legal field.

- For any $n \geq 2$ with $\mathtt{t}_i \in \mathcal{T} \setminus \mathcal{C}$, $\mathtt{map<t}_1\mathtt{, map<} \cdots \mathtt{, t}_n\mathtt{>} \cdots \mathtt{> f}$ is a legal field.

- If $\mathtt{t} \in \mathcal{T} \setminus \mathcal{C}$ then `set<t> f` is a legal field.

- If $\mathtt{t} \in \mathcal{T} \setminus \mathcal{C}$ then `list<t> f` is a legal field.

- If $\mathtt{t} \in \mathcal{T} \setminus \mathcal{C}$ then `t[] f` is a legal field.

- If $i \in \mathbb{N}$ and $\mathtt{t} \in \mathcal{T} \setminus \mathcal{C}$ then $\mathtt{t[}i\mathtt{]\ f}$ is a legal field.

- If `s size` is a field in the same type declaration as `f` with $\mathtt{s} \in \mathcal{I}$ and `size` is declared before `f` [2] then `t[size] f` is a legal field.

Strings

Strings are conceptually a zero terminated sequence of utf8 encoded unicode characters. The in memory representation will try to make use of language features such as java.lang.String or std::u16string.

Strings must not contain 0 characters except for the terminating 0. If the users concept of a *string* allows such data, he has to declare his own data type.

Compound Types

The language offers several compound types. Sets, Lists and auto sized Arrays, i.e. arrays without an explicit size, are basically views onto the same kind of serialized data, i.e. they are a length encoded list of elements of the supplied base type. Arrays are expected to have a constant size, i.e. they are not guaranteed to be resizable. Sets are not allowed to contain the same element twice. All ADTs will be mapped to their closest representation in the target language, while preserving these properties. Maps are viewed as a representation of serializable partial functions. Therefore they can contain other map types as their second type argument, which is basically an instance of currying.

[2] this is required in order to make serialization work; another approach would be to choose a normal form, which would also make declarations robust against reordering

NULL Pointers

NULL Pointers can only be serialized if the respective type is indexed. Otherwise a NULL Pointer is considered an error and will cause the serialization to fail. This is because the resulting file can not be deserialized in all languages, because some languages might choose to represent the respective field e.g. as object. A short example shall illustrate the problem:

```
time{ i64 seconds }
timeStamp{
  ...
  time lastModified;
}
```

In C this will likely look like:

```
struct time { uint64_t seconds; };
struct timeStamp {
  ...
  time lastModified;
}
```

Note that the time object is allocated inside the timeStamp object.

In Java this will likely look like:

```
class time { public long seconds; }
class timeStamp { public time lastModified; }
```

Note that it is legal to store `null` in the lastModified field.

In case of indexed types, the special index 0 is used to serialize NULL. Indexed Types will always be represented by the client languages pointer implementation, i.e. pointer in C, references in Java or access in Ada.

4.1 Examples

This section will present some examples of ill-formed type declarations and brief explanations.

```
tagged EncodedString : string {
  string encoding;
}
```

Error: The built-in type string can not be sub classed.

```
annotation ...
```

5 Invariants

Some invariants can be added to declarations and fields. These invariants can occur at the same place as comments, but can occur in any number. Invariants start with an @ followed by a predicate. Each predicate has to supply a default argument %, such that using only default arguments would not imply a restriction. If multiple predicates are annotated, the conjunction of them forms the invariant. The set of legal predicates is explained below.

If predicates, which are not directly applicable for compound types are used on compound types, they expand to the contents of the compound types, if applicable. Otherwise the usage of the predicate is illegal.

Range

Range restrictions are used to restrict integers and floats.

Applies to fields: Integer, Float.

Signature: `range(min, max)`: $\alpha \times \alpha \longrightarrow \mathit{bool}$

Defaults: obvious.

Examples

```
natural {
  @range(0,%)
  v64 data;
}
positive {
  @range(1,%)
  v64 data;
}
nonNegativeDouble {
  @range(0,%)
  f64 data;
}
```

NonNull

Declares that an indexed field may not be null.

Applies to Field: Any indexed Type.

Signature: `nonnull()`

Defaults: none.

Examples

```
indexed Node {
  @nonnull Node[] edges;
}
```

Unique

Objects stored in a storage pool have to be distinct in their serialized form, i.e. for each pair of objects, there has to be at least one field, with a different value.

NOTE: This can cause difficulties in combination with sub-classing, because the uniqueness property must hold even on the part restricted to the topmost class declared to be unique.

Applies to Declarations of indexed types.

Signature: `unique()`

Defaults: none.

Examples

```
@unique indexed Operator {
  string name;
}
@unique indexed Term {
  Operator operator;
  Term[] arguments;
}
```

Singleton

There is at most one instance of the declaration.

Applies to Declarations.
Signature: `singleton()`
Defaults: none.

Examples

```
@singleton System { ... }
@singleton Data{
 /** Note: if data would not be a singleton itself, it is likely to violate the singleton prope
  System foo;
}
```

Tree

The reference graph below created by objects of this type forms a tree. The type of the objects is irrelevant. Strings and fields with notree annotation, are not taken into account.

Applies to Declarations or Field.
Signature: `tree()`
Defaults: none.

notree

Applies to field.
Signature: `notree()`
Defaults: none.

Examples

```
indexed Sloc{...}
@tree
indexed SyntaktikEntity{
  /** not a tree, because several entities, might share them */
  @notree Sloc sloc;

  SyntaktikEntity[] children;
}
indexed Routine {
  @notree
  Routine[] callers;
  @tree
  Routine[] dominators;
}

@tree
File {
  File[] children;
  /** several files could have the same name,
       but strings are implicitly @notree */
  string name;
  string content;
}
```

Note: In case of the File example, there is no way to violate the tree property. Note: It is legal for trees to form forests.

6 Hints

Hints are annotations that start with a single ! and are followed by a hint name.

Access

Try to use a data structure that provides fast (random) access. E.g. an array list.

Modification

Try to use a data structure that provides fast (random) modification. E.g. an linked list.

Unique

Serialization shall unify objects with exactly the same serialized form. In combination with the @unique restriction, there shall at most be an error reported on deserialization.

Distributed

Use a static map instead of fields to represent fields of definitions. This is usually an optimization if a definition has a lot of fields, but most use cases require only a small subset of them. Because hints do not modify the binary compatibility, some clients are likely to define the fields to be distributed or lazy.

Lazy

Deserialize the fields data only if it is actually used. Lazy implies distributed.

Ignore

The generated code is unable to access the respective field or type of declaration. This will lead to errors, if it is trying nontheless. This option is provided to allow clients to reduce the memory footprint, if needed.

7 On the Choice of Built-In Types

Hier irgendwie erklären, dass es nur typen gibt, die entweder notwendig sind (string) oder überall verfügbar, d.h. man redet im prinzip über den kleinsten gemeinsamen nenner aller prorgrammiersprachen. Der typ bool ist vorhanden, weil die meisten sprachen explizit zwischen integer und bool unterscheiden.

Dass es typen wie unsigned oder positive nicht gibt ist schade, kann aber im zuge einer beschreibungssprache die restriktionen bietet einfach nachgerüstet werden.

Es gibt keinen binary typ, weil dieser trivial definiert werden kann:

```
/** binary as found in Apache Thrift */
binary{ i8[] data }
```

8 On Extensibility and Canonical Declaration Order

Extensibility is an important property. In this section, we develop a normal form of skill definitions, which will allow a robustness of a file format against modification. We will describe the effect of some changes, which can break decoding or encoding capabilities or break the API but not the file format (further ABI).

8.1 Equality of Field Names

Field names are equal, if their lexical representation is equal after converting all characters to lower case. Type declarations must not contain fields with equal names.

8.2 Canonical Declaration Order

A declaration is in canonical declaration order, if all field names are ordered in a lexically ascending way. This design choice is made, because it does not impact the serialization or deserialization speed and provides a bit of robustness against changes in definitions. To do (14)

8.3 A Rule of Thumb

A change of the organization of input files or the order of their definition has no effect.

The addition of new declarations has no effect.

A change regarding comments has no significant effect.

A change in restrictions of any kind may break the ABI, probably only for some language bindings. It will most certainly render some files illegal, which were legal before.

A change of hints shall no significant effect, although some applications can stop working after a change of hints, e.g. if they access fields which are annotated with `!ignore`.

Inserting or removing the keyword `const` may break compatibility. To do (15)

Changing the value of a constant will break the ABI.[3]

Inserting or removing the keyword `auto` will break ABI, but not the API.

Any change of the structure of existing declarations, i.e. changing the modifier, adding or removing fields, etc., will break compatibility as a whole.

9 Serialization

This section is about representing objects of an arbitrary legal type $\mathcal{T}$ as a sequence of bytes. We will call this sequence *stream*, its formal Type will be named S, the current stream will be named s. We will assume that there is an implicit conversion between fixed sized integers[4] and streams. We also make use of a stream concatenation operator $\circ : S \times S \longrightarrow S$.

Before being able to understand the serialization of a whole graph of objects into a file, we have to fix a serialization function, which turns an arbitrary object into a stream. Let $[\![\_]\!] : \mathcal{T} \longrightarrow S$ be the translation function, which serializes an object of any type into a stream.

In the following definitions, let o be the object to be serialized and T be its type.

- The NULL-Pointer, which is legal in case of indexed types is serialized as $[\![\texttt{NULL}]\!] = 0$
- For any o of annotation type, the serialization is defined as $[\![o]\!] = sizeOf([\![o']\!]) \circ [\![o']\!]$, i.e. the serialization of the actual payload is proceeded by the size of the payload. Therefore annotation fields can contain arbitrary content.
- For any o of a tagged type, the serialization is defined as $[\![o]\!] = [\![name(T)]\!] \circ [\![o']\!]$, where o' is o treated as if its type would not be tagged anymore, i.e. serialized tagged types are proceeded by their type names. If T is indexed as well, the indexed rule proceeds the tagged rule, i.e. the type name is stored in the storage pool, but not in a field.
- For any o of an unmodified user type, i.e. $mod(T) = \emptyset$, with field declarations $t_i\ f_i$, the serialization is defined as $[\![o]\!] = [\![f_0]\!] \circ \cdots \circ [\![f_n]\!]$. The serialization order equals the canonical declaration order, as explained above.
- For any o of a user type not treated above, the serialization is defined as $[\![o]\!] = indexOf(o)$, i.e. the index of the object inside the respective storage pool.
- The serialization of a string is its index in the string pool. The serialization of a string inside the string pool is its representing utf8 sequence followed by exactly one terminating 0 character. Interfaces requiring strings without terminating 0 character will add/remove them automatically.[5]
- Booleans are serialized using $[\![\top]\!] = 0xFF$ and $[\![\bot]\!] = 0x00$, i.e. a byte is used, which is all 1s in case of true and all 0s in case of false.
- For any o of fixed size integer type $[\![o]\!] = o$.

[3] Which is btw. the very purpose of constants.

[4] As well as between fixed sized floating point numbers, because we define them to be IEEE-754 encoded 32-/64-bit sequences.

[5] If the stored string happens to be a type name, it is guaranteed that a lowercase conversion of the very string is idempotent.

- v64, sizes and lengths are serialized using the variable length coding explained in appendix A: $\llbracket o \rrbracket = encode(o)$ with encode as in listing 6. This coding favors small natural numbers.

- For any o of floating point type, the serialization is $\llbracket o \rrbracket = o$, i.e. the in memory represenation is written into the stream. This assumes floats to be encoded according to IEEE-754.

- For any variably sized array o, $\llbracket o \rrbracket = \llbracket size(o) \rrbracket \circ \llbracket o[0] \rrbracket \circ \cdots \circ \llbracket o[size(o) - 1] \rrbracket$. Note, that size is treated as if it were a field of type `v64`.

- For any fix sized array o or any array with a size that is the value of another field, $\llbracket o \rrbracket = \llbracket o[0] \rrbracket \circ \cdots \circ \llbracket o[size(o) - 1] \rrbracket$.

- Lists and Sets are serialized as if they were variable sized arrays.

- Maps are serialized, as if they were pairs of elements of their argument types. Note that this will cause a nested map type such as `map<T,map<U,V>>` to be serialized using a schema $\llbracket size(o) \rrbracket \circ \llbracket o.t_1 \rrbracket \circ \llbracket size(o[t_1]) \rrbracket \circ \llbracket o[t_1].u_1 \rrbracket \circ \llbracket o[t_1].v_1 \rrbracket \circ \llbracket o[t_1].u_2 \rrbracket \circ \cdots \circ \llbracket size(o[t_2]) \rrbracket \circ \cdots \circ \llbracket o[t_n].v_m \rrbracket$

blablabla pools, ...

File Layout:

```
v64 size
string[size] stringPool

bool lastStringIsDefinition

while(next!=EOF){
  v64 poolName
  v64 sizeBytes
  v64 sizeCount
  opt(v64 basePoolStartIndex; iff extends)
  [[ T[sizeCount] elements ]]
}
```

10 Deserialization

Deserialization is mostly straight forward.

The general strategy is:

- the string pool is deserialized and a map from index to strings is created.

- all other objects are deserialized. Any fields referring to indexed types are stored in an adequate data structure.

- fields referring to indexed types are filled with pointers to the actual instances.

- the root object is deserialized

Of course, there can be optimizations in some languages. E.g. in C++, one can simply store create all Objects in one pass and store indices to the respective pools in the pointer typed fields by using an unsafe pointer/integer conversion, which can be corrected in a second pass, where those indices are replaced by the correct pointer values.

10.1 Examples

Nice example in C++:

```
#include <stdint.h>
#include <string>
[...some other bouilerplate includes...]
struct SLoc {
  uint16_t line;
  uint16_t column;
  std::string* path;
};
struct Block {
  std::string* tag;
  SLoc* begin;
  SLoc* end;
  std::string* image;
};
struct IfBlock : public Block {
  Block thenBlock;
};
struct ITEBlock : public IfBlock {
  Block elseBlock;
};
[...plus some boilerplate code for visitors, iostreams etc. ...]
```

Nice example in Java:

```
class SLoc {
  public short line;
  public short column;
  public String path;
}
class Block {
  final public String tag() { return this.getClass().getName(); }
  public SLoc begin;
  public SLoc end;
  public String image:
}
class IfBlock extends Block {
  public Block thenBlock;
}
class ITEBlock extends IfBlock {
  public Block elseBlock;
}
[...some read and write code, plus some visitors...]
```

Nice example in LaTeX-formulas:

```
$(line, column, path) \in SLoc
  \subseteq \mathbb{Z} \times \mathbb{Z} \times string$
```

```
$(begin, end, image) \in Block
  \subseteq SLoc \times SLoc \times string$

$(super, thenBlock) \in IfBlock
  \subseteq Block \times Block$

$(super, elseBlock) \in ITEBlock
  \subseteq IfBlock \times Block$
```

Which looks like:

$(line, column, path) \in SLoc \subseteq \mathbb{Z} \times \mathbb{Z} \times string$

$(begin, end, image) \in Block \subseteq SLoc \times SLoc \times string$

$(super, thenBlock) \in IfBlock \subseteq Block \times Block$

$(super, elseBlock) \in ITEBlock \subseteq IfBlock \times Block$

Note: The incentive of the LaTeX-output is to provide a mechanism for users to formalize their file format using mechanisms, that are or can not be available as a specification language. E.g. the sentence "The path of a SLoc points to a valid file on the file system and the line and column form a valid location inside that file." can not be verified in a static manner. This is because the correctness of the property depends not only on the content to be verified, but on the verifying environment as well.

11 Case Study: Skill Encoded XML

Although it is not very clever to use skill for encoding xml files, because one basically looses all benefits from both worlds, we will do so as demonstration for the compression yielded by the skill serialization scheme. Honestly most effects will be obtained from strings being stored in the string pool. Because most of the validation mechanisms directly built into xml are not required in skill and for the sake of simplicity, we will strip xml to its bare payload:

Listing 5: Skill Encoded XML

```
XML {
  string xmlDecl;
  Element element;
}
Element {
  string name;
  map<string, string> attributes;
  /** @note we will supply the empty string, if no
            content is present */
  string content;
  Element[] children;
}
```

To do (16)

To do (17)

To do (18)

12 Future Work

Serialisierungsnormalform? (Robustheit gegenüber Änderungen in der Spezifikation)

XML output mit XML Schema.

Das neue Serialisierungsschema erlaubt es einen Viewer zu bauen, der Definition+Datei anzeigen kann.

Integration der Definition in die Serialisierte Form, damit man die Daten generisch prüfen und anzeigen kann.

Fun fact: Garbage Collection for serializable objects comes for free, if objects are always held in storage pools.

To do...

□ 1 (p. 1): blablabla

□ 2 (p. 1): muss noch schöner werden

□ 3 (p. 1): ensure that there are no compiler related examples, because those can be very confusing

□ 4 (p. 1): proof read the whole thing to account for changes resulting from the discussion with EP

□ 5 (p. 1): proof!

□ 6 (p. 1): cite w3c

□ 7 (p. 2): brr

□ 8 (p. 2): ref David Lamb

□ 9 (p. 4): Appendix with a list of all identifiers which form reserved words in one of the languages above, including our keywords

□ 10 (p. 4): more comments, nicer, we will use this as running example

□ 11 (p. 6): brrr sprache!

□ 12 (p. 6): Ehrlich gesagt sollte man hier irgendwie das LaTeX-backend beschreiben, das würde meistens erklären, was die einzelnen wörter bedeuten.

□ 13 (p. 6): sprache!

□ 14 (p. 13): Hier MUSS noch eine Ordnung bezüglich Typen rein, die vor der lexikalischen Ordnnug stattfindet, sonst kann es sein, dass ein size feld erst nach dem betroffenen array liegt und dann ist die deserialisierung unmöglich

□ 15 (p. 13): really?

□ 16 (p. 17): compare size of some svg files

□ 17 (p. 17): compare speed of load/store of those svg files

□ 18 (p. 17): some final comments to say, that the comparison is of course not completely fair, and that it is advised against mixing xml and skill in most cases

Part I

Appendix A: Variable Length Coding

Size and Length information is stored as variable length coded 64 bit unsigned integers (aka C's `uint64_t`). The basic idea is to use up to 9 bytes, where any byte starts with a 1 iff there is a consecutive byte. This leaves a payload of 7 bit for the first 8 bytes and 8 bits of payload for the ninth byte. This is very similar to the famous utf8 encoding and is justifed, as it is the case with utf8, by the assumption, that smaller numbers are a lot more likely. It has the nice property, that there are virtually no numerical size limitations. The following small C++ functions will illustrate the algorithm:

Listing 6: Variable Length Encoding

```
uint8_t* encode(uint64_t v){
  // calculate effective size
  int size = 0;
  {
    auto q = v;
    while(q){
      q >>= 7;
      size++;
    }
  }
  if(!size){
    auto rval = new uint8_t[1];
    rval[0]=0;
    return rval;
  }else if(10==size)
    size = 9;

  // split
  auto rval = new uint8_t[size];
  int count=0;
  for(;count<8&&count<size-1;count++){
    rval[count] = v >> (7*count);
    rval[count] |= 0x80;
  }
  rval[count] = v >> (7*count);
  return rval;
}
```

Listing 7: Variable Length Decoding

```
uint64_t decode(uint8_t* p){
  int count = 0;
  uint64_t rval = 0;
  register uint64_t r;
  for(;count<8 && (*p)&0x80; count++, p++){
    r = p[0];
    rval |= (r&0x7f)<<(7*count);
  }
  r = p[0];
  rval |= (8==count?r:(r&0x7f))<<(7*count);
  return rval;
}
```