Unifying Fixnum and Bignum into Integer

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Announcement

- Ruby 2.4 unify Fixnum and Bignum into Integer
  [Feature #12005] by naruse
- For Ruby programmers
  - Fixnum class and Bignum class are removed
  - 1.class and (2**100).class returns Integer instead of Fixnum and Bignum
  - The constants, Fixnum and Bignum, references Integer class
    (NameError will not occur)
- For C programmers
  - No internal representation change
  - The global constants, rb_cFixnum and rb_cBignum, are removed
    (compilation error will occur)
  - Class based dispatch doesn't work anymore
    Use FIXNUM_P(obj) and RB_TYPE_P(obj, T_BIGNUM)
  - RUBY_INTEGER_UNIFICATION macro is defined
    (for extension library supporting old and new Ruby)

Fixnum and Bignum

Ruby 2.3 has three classes to represent integers

- Integer: abstract super class
  - Fixnum: class for small integers
  - Bignum: class for big integers
- Examples
  - 1.class => Fixnum
  - (2**100).class => Bignum

Integer Unification

Ruby 2.4 has one class to represent integers

- Integer: concrete class
- Examples
  - 1.class => Integer
  - (2**100).class => Integer

Integer Implementations

The range of Fixnum varies

- 32bit CRuby (ILP32): -2^{30} to $2^{30}-1$
- 64bit CRuby (LLP64): -2^{30} to $2^{30}-1$
- 64bit CRuby (LP64): -2^{62} to $2^{62}-1$
- JRuby: -2^{63} to $2^{63}-1$

The range is not portable

Integer Specification

- The specification
  - ISO/IEC 30170:2012 Information technology -- Programming languages -- Ruby
  - JIS X 3017:2011 プログラム言語Ruby
- It specifies:
  - There is Integer class which range is unbounded
  - Implementation may (or may not) define subclasses of Integer
  - I.e. Fixnum and Bignum class are not defined (but permitted)
- Ruby 2.3 and Ruby 2.4 conforms the specification
- Conforming program should not depend on Fixnum, Bignum and their range

Fixnum and Bignum is Implementation Detail

- The range of Fixnum varies
  Ruby program should not depend on the range for portability
- The spec. doesn't define Fixnum and Bignum
  Ruby program should not depend on them

Integer Unification for Ruby Programmers

Pros

- Cannot misuse Fixnum and Bignum wrongly
- Learn Ruby easier
- Simplify documents
- Simpler, cleaner, and more mathematical

Cons

- Incompatibility

Wrong Use of Fixnum

lib/rubygems/specification.rb:

```
unless specification_version.is_a?(Fixnum)
  raise Gem::InvalidSpecificationException,
        'specification_version must be a Fixnum (did you mean version?)'
end
```

- This means that valid specification_version is
  -2^{30} to $2^{30}-1$ in 32bit CRuby (ILP32),
  -2^{30} to $2^{30}-1$ in 64bit CRuby (LLP64),
  -2^{62} to $2^{62}-1$ in 64bit CRuby (LP64) and
  -2^{63} to $2^{63}-1$ in JRuby.
- This is not the expected meaning

Cannot Use Fixnum and Bignum Wrongly on Ruby 2.4

- Cannot depend the Fixnum range
  obj.is_a?(Fixnum) means obj.is_a?(Integer)
- REPL doesn't encourage Fixnum
  irb> 1.class
  => Integer (Fixnum until Ruby 2.3)

Learn Ruby Easier

- Everyone knows 1 is an integer
  → Not necessary
- Most people doesn't know 1 is a Fixnum (except (Lisp programmers))
  → Necessary

Simplify Textbooks

- No need to teach Fixnum and Bignum
- Example: Programming Ruby, 2nd edition, p.59

  Ruby supports integers and floating-point numbers. Integers can be any length (up to a maximum determined by the amount of free memory on your system). Integers within a certain range (normally -2^{30} to $2^{30}-1$ or -2^{62} to $2^{62}-1$) are held internally in binary form and are objects of class Fixnum. Integers outside this range are stored in objects of class Bignum (currently implemented as a variable-length set of short integers). This process is transparent, and Ruby automatically manages the conversion back and forth.

  ↓

  Ruby supports integers and floating-point numbers. Integers can be any length (up to a maximum determined by the amount of free memory on your system).

Simplify Documents

rdoc forces us to describe document for each method

- Until Ruby 2.3
  - Document Fixnum#foo and Bignum#foo separately
    It causes duplicated document
  - "ri foo" shows both Fixnum#foo and Bignum#foo
    The duplicated document shown
- Since Ruby 2.4
  - Document only Integer#foo
  - "ri foo" doesn't show duplicated document

Simpleer, Cleaner, and more Mathematical

- Simple
  Less classes
- Clean
  No implementation details
- Correspond to mathematics
  - Mathematics: 1 is an integer
  - Ruby: 1.class => Integer

Ruby Level Incompatibility

- Fixnum and Bignum references Integer
- Fixnum range is hidden
- Metaprogramming and DSL

Fixnum and Bignum References Integer

- Fixnum and Bignum references Integer

```
irb> Fixnum
=> Integer
irb> Bignum
=> Integer
```

  NameError will not occur but

  - Fixnum == Bignum => true
  - 1.is_a?(Bignum) => true
  - (2**100).is_a?(Fixnum) => true

- Fixnum and Bignum should not be removed until EOL of Ruby 2.3, at least

Fixnum Range is Hidden

The code for finding Fixnum range will be broken:

- test/ruby/test_integer_comb.rb:

```
max = 1
max *= 2 while (max–1).class == Fixnum
FIXNUM_MAX = max/2–1
```

  This is an infinite loop on Ruby 2.4

- Recommended solution: Don't depend on Fixnum range
- CRuby only non-recommended solution:

```
require 'rbconfig/sizeof'  # available since Ruby 2.1
FIXNUM_MIN = –(1 << (8 * RbConfig::SIZEOF['long'] – 2))
FIXNUM_MAX = (1 << (8 * RbConfig::SIZEOF['long'] – 2)) – 1
```

Metaprogramming and DSL may be Broken

- Metaprogramming
  - mathn.rb defined a method in Fixnum and Bignum
    Solution: Define a method in Integer
  - activesupport prepends NumericWithFormat to Fixnum and Bignum
    Solution: prepends to Integer
- DSL
  - Fixnum and Bignum is not distinguishable
  - Example: Sequel
    http://sequel.jeremyevans.net/rdoc/files/doc/release_notes/4_35_0_txt.html

```
DB.create_table(:table) do
  add_column :column, Bignum # Bignum means 64-bit integer column
end
```

    Solution: Use a symbol. :Bignum instead of Bignum

Integer Unification for C programmers

Pros

- Nothing

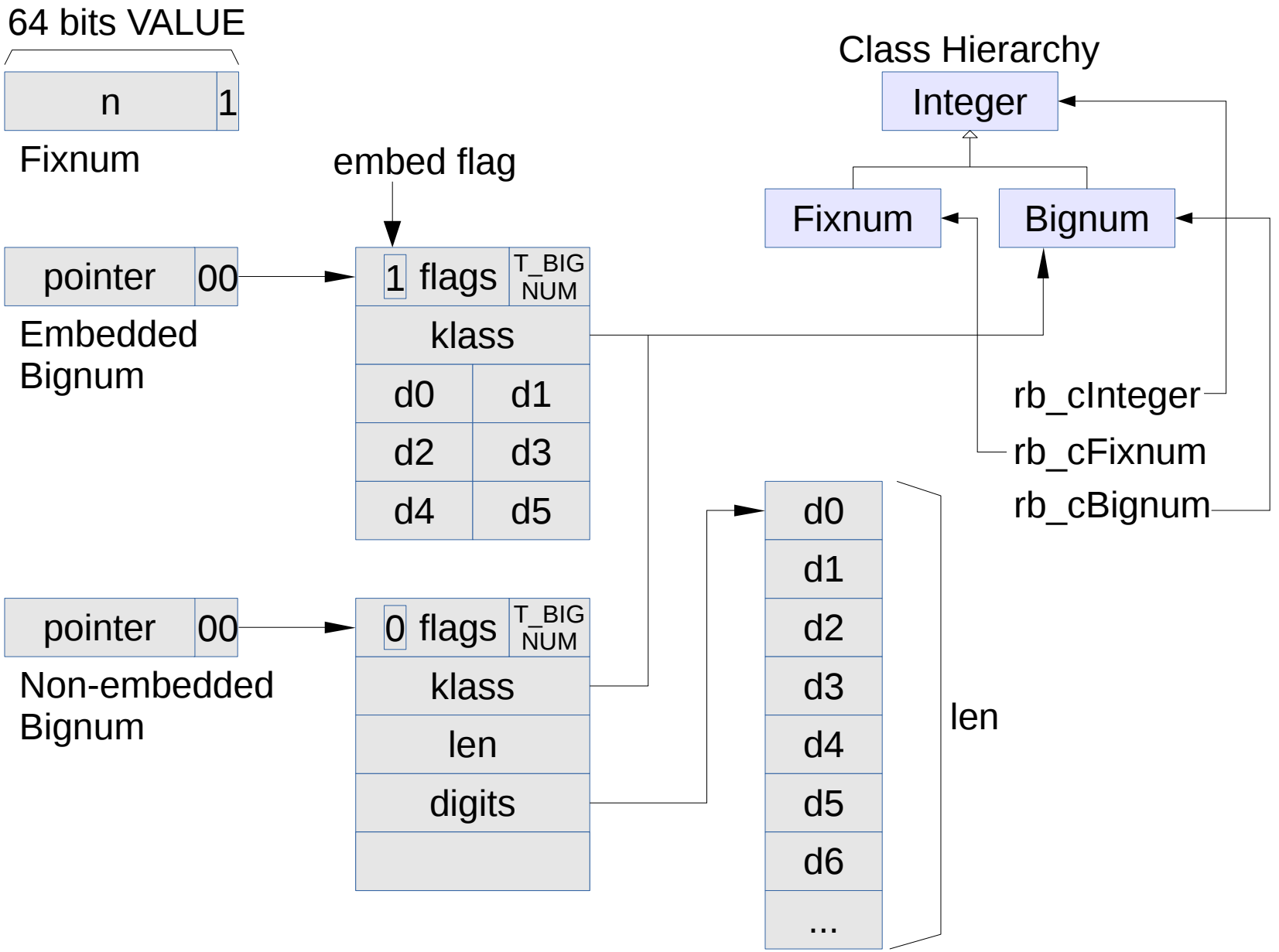
Cons

- Incompatibility

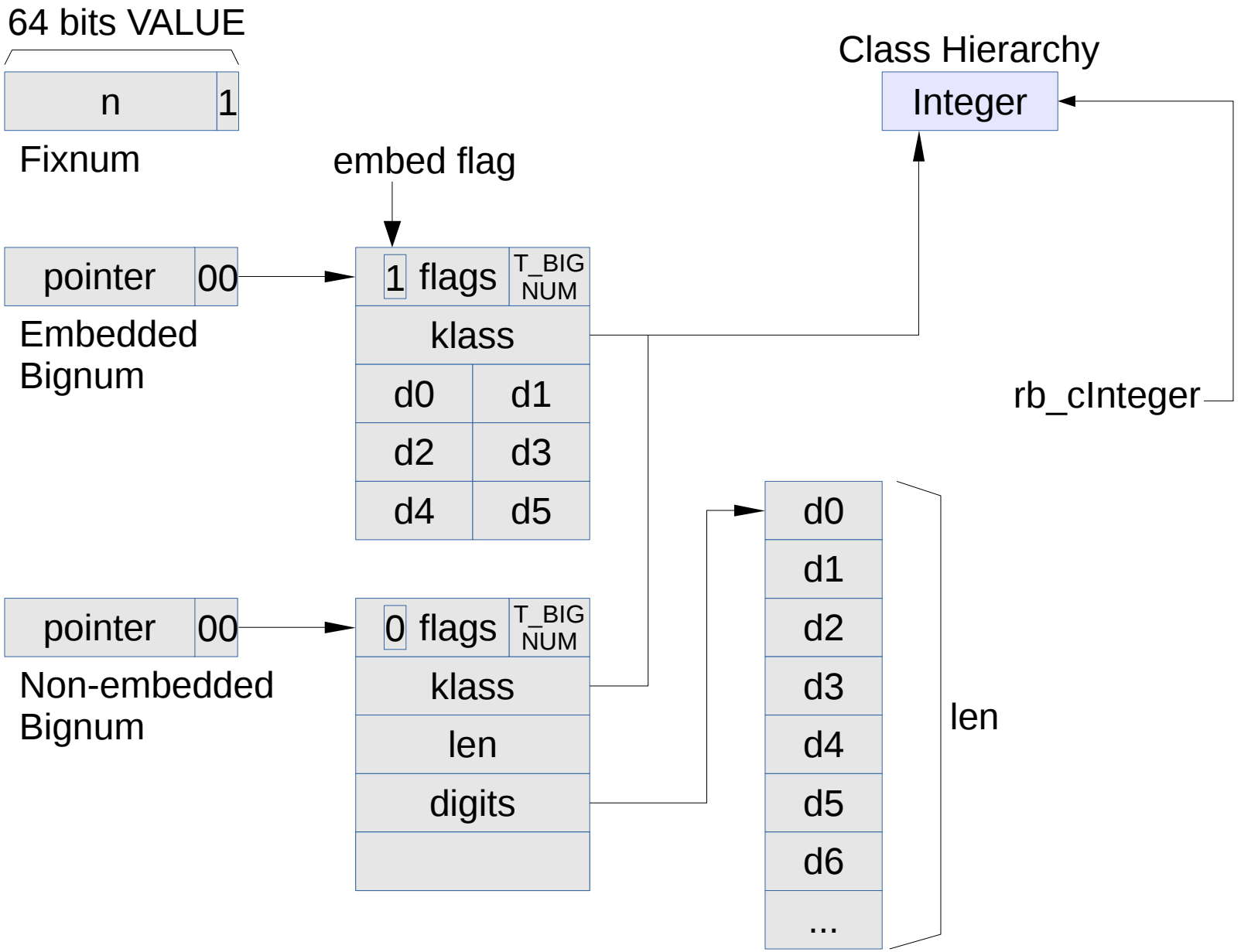
Integer Unification at C-level

- The internal representation is not changed
  Fixnum/Bignum distinction still exist at C-level
- No Fixnum/Bignum class as Ruby-level
- The global variables for the classes,
  rb_cFixnum and rb_cBignum, are not defined
  This causes compilation error for problematic
  extension library

Integer Representation of Ruby 2.3



Integer Representation of Ruby 2.4



Update Extension Library

- Class comparison:
  - rb_class_of(obj) == rb_cFixnum
    → FIXNUM_P(obj)
  - rb_class_of(obj) == rb_cBignum
    → RB_TYPE_P(obj, T_BIGNUM)
- Method definition:
  rb_define_method(rb_cFixnum, "foo", f1, ...)
  rb_define_method(rb_cBignum, "foo", f2, ...)
  →
  static VALUE f(...) {
    return FIXNUM_P(self) ? f1(...) : f2(...);
  }
  rb_define_method(rb_cInteger, "foo", f, ...)

Distinguish Ruby 2.3 and 2.4

- RUBY_INTEGER_UNIFICATION macro is defined since Ruby 2.4
- Use following #ifdef
  #ifdef RUBY_INTEGER_UNIFICATION
  code for Ruby 2.4 or later
  #else
  code for Ruby 2.3 or former
  #endif

Affected Extension Libraries

Most libraries to dump/load objects need to be updated

Already modified:

- ext/json
- msgpack https://github.com/msgpack/msgpack-ruby/pull/115
- syck https://github.com/tenderlove/syck/issues/17
- yajl https://github.com/chef/ffi-yajl/pull/80
- oj https://github.com/ohler55/oj/issues/305
- ox https://github.com/ohler55/ox/commit/f826190eeeb3cc43f810de5b630a36b78f709dc2
- ruby-gnome2 https://github.com/ruby-gnome2/ruby-gnome2/commit/dccaf485edd589830e7c37bfde4e78cec147fbaf
- etc.

Version Dependencies

- Several libraries are already modified
- Need to release to use them
- Minor version up (1.3 to 1.4) is better
- Major version up (1.3 to 2.0) may cause problems
  Gems with pessimistic version dependency (~>) must also be updated
- See details for the article by @hsbt
  https://www.hsbt.org/diary/20160829.html#p01

Fixnum/Bignum Agnostic API

- There are few C-level APIs which works Fixnum and Bignum seamlessly
  Example: NUM2LONG,rb_integer_pack/unpack
- More APIs if people wants...
  Why we have no C-level APIs for add/sub/mul/div/mod working both Fixnum and Bignum?
  rb_funcall is good enough for us?

Benefits versus Incompatibility

- The benefits are mostly for beginners
- Fixnum/Bignum is not a big problem for experienced programmers
- Incompatibility annoys people
  Especially when extension library is not updated immediately

Supported Commiters

- naruse: prevents the wrong use of Fixnum
- akr: simpler documentation
- martin: serious benefits in documentation and learning
- mrkn: more mathematical
- matz: much cleaner & simpler

Summary

- Fixnum and Bignum is unified into Integer at Ruby level
  - Less pitfall
  - Easier learning
  - Simpler documents
- Incompatibility
  - Update your library