Toward efficient Ruby 2.1

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Agenda

- Ruby 2.1 Schedule
- Ruby 2.1 new “internal” features
  - Internal object management hooks
    - Object allocation tracing
    - GC hooks
  - **RGenGC: Restricted Generational Garbage Collection ← Today’s main topic**
- Ruby 2.1 expected “internal” features
  - Sophisticated inline cache invalidation mechanism
  - Memory efficient string management
  - Useful debugger

Summary

- We are implementing new features and improving Ruby's quality for Ruby 2.1
- Especially introducing "Generational garbage collector" which I'm working on will improve huge performance
- Ruby 2.1 is currently scheduled on Dec 25, 2013

Quoted “2.1”

“2:1 And there went a man of the house of Levi, and took to wife a daughter of Levi.”

- Book of Exodus

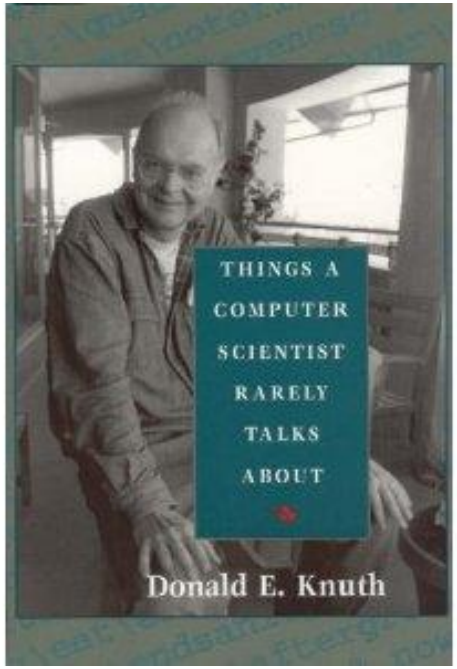
“2:1 さて、レビの家のひとりの人が行ってレビの娘をめとった。”

- 出エジプト記

Quoted “2.1”

In this presentation,
there are some quoted “2.1” sentence.

Idea of “Quoting” is from
“Things a Computer Scientist Rarely Talks About”
“コンピュータ科学者がめったに語らないこと”
by Donald E. Knuth
But no consideration in this presentation about them.



Who am I ?

- 笹田耕一 (Koichi Sasada)
  - Matz team at Heroku, Inc.
    - Full-time CRuby development
  - CRuby/MRI committer
    - Virtual machine (YARV) from Ruby 1.9
    - YARV development since 2004/1/1

Matz team at Heroku, Inc. Hierarchy

Matz @ Shimane
Title collector

Communication
with Skype

ko1 @ Tokyo
EDD developer

Nobu @ Tochigi
Drunker

Recent status

- 5/2　I got sprain…
- 5/27 I got cold…

- All: Please care about yourself
  - Especially, do not walk with book reading

My leg with a bivalve cast

Quoted “2.1”

“Object-oriented scripting language Ruby is a programming language designed by Matsumoto.”

- Efficient Implementation of Ruby Virtual Machine

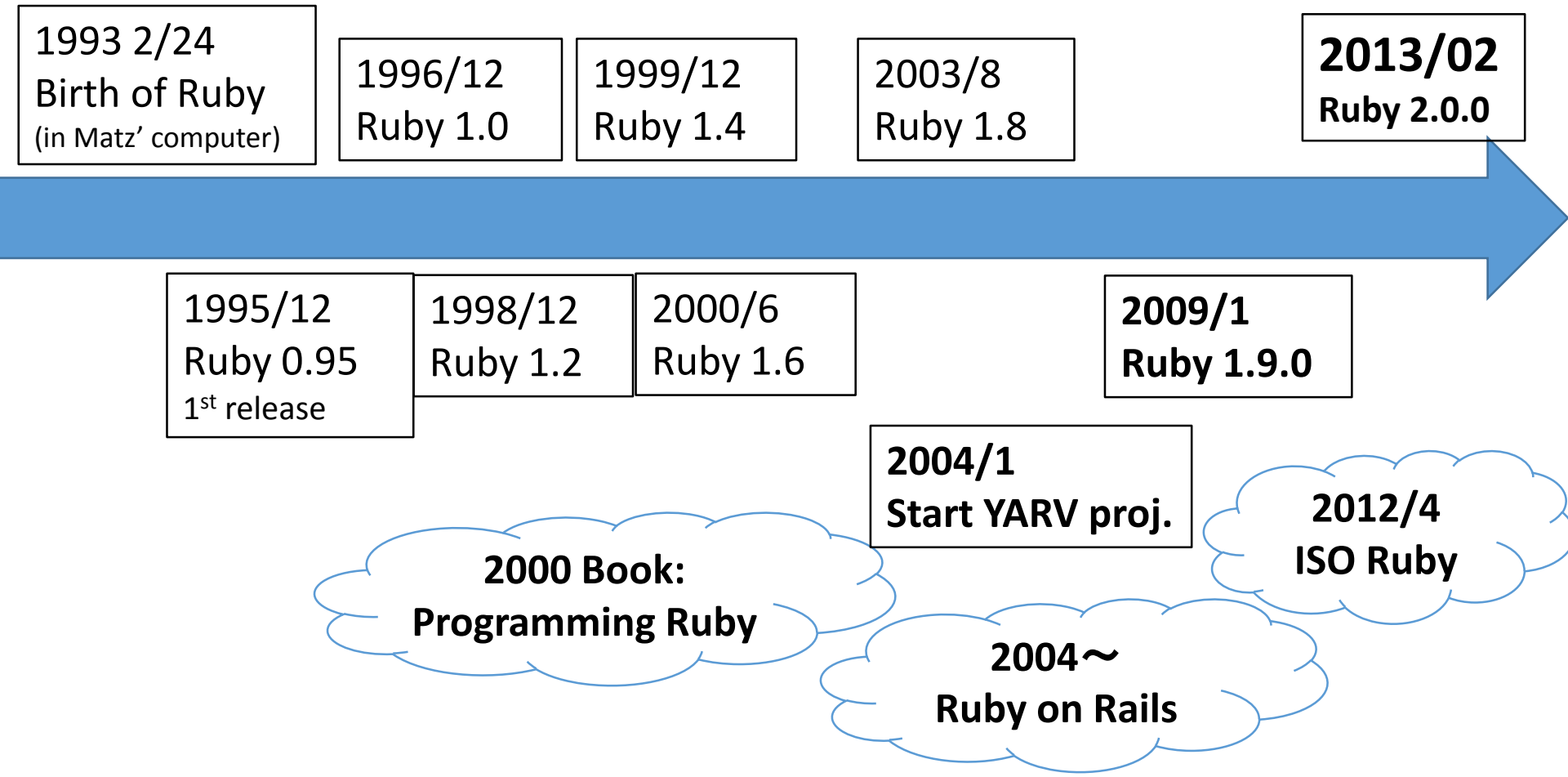
Doctoral thesis by Koichi Sasada

“オブジェクト指向スクリプト言語Rubyは，松本によって設計されたプログラミング言語である．”

- 高速なRuby用仮想マシンの開発

笹田耕一，博士論文

Ruby's rough history



Quoted “2.1”

“2.1 Changes from Ruby 1.9

Added and modified libraries from Ruby 1.9 are follows”

- Programming Ruby 1.9 Library edition

by Dave Thomas, with Chad Fowler and Andy Hunt

“2.1 Ruby 1.9のライブラリの変更点

Ruby 1.9で追加または変更されたライブラリは次のとおりです。”

- プログラミングRuby 1.9 ライブラリ編

Ruby 2.0

- New features (see Rubyist Magazine)
  - Keyword arugments
  - Refinements
  - Module#prepend
- Ruby 2.0.0-p195 was already released

NEWS file of Ruby 2.0

Many new features!!

-*- rdoc -*-

= NEWS for Ruby 2.0.0

This document is a list of user visible feature changes made between

releases except for bug fixes.

Note that each entry is kept so brief that no reason behind or

reference information is supplied with. For a full list of changes

with all sufficient information, see the ChangeLog file.

== Changes since the 1.9.3 release

=== C API updates

* NUM2SHORT() and NUM2USHORT() added. They are similar to NUM2INT, but short.

* rb_newobj_of() and NEWOBJ_OF() added. They create a new object of a given class.

=== Library updates (outstanding ones only)

* builtin classes

  * Array

    * added method:

      * Array#bsearch for binary search.

    * incompatible changes:

      * random parameter of Array#shuffle! and Array#sample now

        will be called with one argument, maximum value.

      * when given Range arguments, Array#values_at now returns nil for each

        value that is out-of-range.

  * Enumerable

    * added method:

      * added Enumerable#lazy method for lazy enumeration.

  * Enumerator

    * added method:

      * added Enumerator#size for lazy size evaluation.

    * extended method:

      * Enumerator.new accept an argument for lazy size evaluation.

  * ENV

    * aliased method:

      * ENV.to_h is a new alias for ENV.to_hash

  * Fiber

    * incompatible changes:

      * Fiber#resume cannot resume a fiber which invokes "Fiber#transfer".

  * File

    * extended method:

      * File.fnmatch? now expands braces in the pattern if

        File::FNM_EXTGLOB option is given.

  * GC

    * improvements:

      * introduced the bitmap marking which suppresses to copy a memory page

        with Copy-on-Write.

      * introduced the non-recursive marking which avoids unexpected stack overflow.

  * GC::Profiler

    * added method:

      * added GC::Profiler.raw_data which returns raw profile data for GC.

  * Hash

    * added method:

      * added Hash#to_h as explicit conversion method, like Array#to_a.

    * extended method:

      * Hash#default_proc= can be passed nil to clear the default proc.

  * Kernel

    * added method:

      * added Kernel#Hash conversion method like Array() or Float().

      * added Kernel#using, which imports refinements into the current scope.

        [experimental]

      * added Kernel#__dir__ which returns a current dirname.

      * added Kernel#caller_locations which returns an array of

        frame information objects.

    * extended method:

      * Kernel#warn accepts multiple args in like puts.

      * Kernel#caller accepts second optional argument 'n' which specify

        required caller size.

      * Kernel#to_enum and enum_for accept a block for lazy size evaluation.

    * incompatible changes:

      * system() and exec() closes non-standard file descriptors

        (The default of :close_others option is changed to true by default.)

      * respond_to? against a protected method now returns false unless

        the second argument is true.

      * __callee__ has returned to the original behavior, and now

        returns the called name but not the original name in an

        aliased method.

      * Kernel#inspect does not call #to_s anymore

        (it used to call redefined #to_s).

  * LoadError

    * added method:

      * added LoadError#path method to return the file name that could not be

        loaded.

  * Module

    * added method:

      * added Module#prepend which is similar to Module#include,

        however a method in the prepended module overrides the

        corresponding method in the prepending module.

      * added Module#refine, which extends a class or module locally.

        [experimental]

      * added Module#refinements, which returns refinements defined in the

        receiver. [experimental]

      * added Module#using, which imports refinements into the receiver.

        [experimental]

      * extended method:

        * Module#define_method accepts a UnboundMethod from a Module.

        * Module#const_get accepts a qualified constant string, e.g.

          Object.const_get("Foo::Bar::Baz")

  * Mutex

    * added method:

      * added Mutex#owned? which returns the mutex is held by current

        thread or not. [experimental]

    * incompatible changes:

      * Mutex#lock, Mutex#unlock, Mutex#try_lock, Mutex#synchronize

        and Mutex#sleep are no longer allowed to be used from trap handler

        and raise a ThreadError in such case.

      * Mutex#sleep may spurious wakeup. Check after wakeup.

  * NilClass

    * added method:

      * added nil.to_h which returns {}

  * Process

    * added method:

      * added getsid for getting session id (unix only).

  * Range

    * added method:

      * added Range#size for lazy size evaluation.

      * added Range#bsearch for binary search.

  * Signal

    * added method:

      * added Signal.signame which returns signal name

    * incompatible changes:

      * Signal.trap raises ArgumentError for

        when SEGV, BUS, ILL, FPE and VTALRM

        are specified.

  * String

    * added method:

      * added String#b returning a copied string whose encoding is ASCII-8BIT.

    * change return value:

      * String#lines now returns an array instead of an enumerator.

      * String#chars now returns an array instead of an enumerator.

      * String#codepoints now returns an array instead of an enumerator.

      * String#bytes now returns an array instead of an enumerator.

  * Struct

    * added method:

      * added Struct#to_h returning values with keys corresponding to the

        instance variable names.

  * Thread

    * added method:

      * added Thread#thread_variable_get for getting thread local variables

        (these are different than Fiber local variables).

      * added Thread#thread_variable_set for setting thread local variables.

      * added Thread#thread_variables for getting a list of the thread local

        variable keys.

      * added Thread#thread_variable? for testing to see if a particular thread

        variable has been set.

      * added Thread#backtrace_locations which returns similar information of

        Kernel#caller_locations.

    * incompatible changes:

      * Thread#join and Thread#value now raises a ThreadError if target thread

        is the current or main thread.

  * Time

    * change return value:

      * Time#to_s returned encoding defaults to US-ASCII but automatically

        changes to Encoding.default_internal if it is

        not nil.

  * TracePoint

    * new class. This class is replacement of set_trace_func.

      Easy to use and efficient implementation.

  * toplevel

    * added method:

      * added main.define_method which defines a global function.

  * cgi

    * Add HTML5 tag maker.

    * CGI#header has been renamed to CGI#http_header and

      aliased to CGI#header.

    * When HTML5 tagmaker called, overwrite CGI#header,

      CGI#header function is to create a <header> element.

  * iconv

    * iconv has been removed. Use String#encode instead.

  * io/wait

    * new features:

      * added IO#wait_writable method.

      * added IO#wait_readable method as alias of IO#wait.

  * net/http

    * new features:

      * Proxies are now automatically detected from the http_proxy environment

        variable. See Net::HTTP::new for details.

      * gzip and deflate compression are now requested for all requests by

        default. See Net::HTTP for details.

      * SSL sessions are now reused across connections for a single instance.

        This speeds up connection by using a previously negotiated session.

    * new methods:

      * Net::HTTP#local_host

      * Net::HTTP#local_host=

      * Net::HTTP#local_port

      * Net::HTTP#local_port=

    * extended method:

      * Net::HTTP#connect uses local_host and local_port if specified.

  * net/imap

    * new methods:

      * Net::IMAP.default_port

      * Net::IMAP.default_imap_port

      * Net::IMAP.default_tls_port

      * Net::IMAP.default_ssl_port

      * Net::IMAP.default_imaps_port

  * objspace

    * new method:

      * ObjectSpace.reachable_objects_from(obj)

  * openssl

    * Consistently raise an error when trying to encode nil values. All instances

      of OpenSSL::ASN1::Primitive now raise TypeError when calling to_der on an

      instance whose value is nil. All instances of OpenSSL::ASN1::Constructive

      raise NoMethodError in the same case. Constructing such values is still

      permitted.

    * TLS 1.1 & 1.2 support by setting OpenSSL::SSL::SSLContext#ssl_version to

      :TLSv1_2, :TLSv1_2_server, :TLSv1_2_client or :TLSv1_1, :TLSv1_1_server

      :TLSv1_1_client. The version being effectively used can be queried

      with OpenSSL::SSL#ssl_version. Furthermore, it is also possible to

      blacklist the new TLS versions with OpenSSL::SSL::OP_NO_TLSv1_1 and

      OpenSSL::SSL::OP_NO_TLSv1_2.

    * Added OpenSSL::SSL::SSLContext#renegotiation_cb. A user-defined callback

      may be set which gets called whenever a new handshake is negotiated. This

      also allows to programmatically decline (client) renegotiation attempts.

    * Support for "0\n" splitting of records as BEAST mitigation via

      OpenSSL::SSL::OP_DONT_INSERT_EMPTY_FRAGMENTS.

    * OpenSSL requires passwords for decrypting PEM-encoded files to be at least

      four characters long. This led to awkward situations where an export with

      a password with fewer than four characters was possible, but accessing the

      file afterwards failed. OpenSSL::PKey::RSA, OpenSSL::PKey::DSA and

      OpenSSL::PKey::EC therefore now enforce the same check when exporting a

      private key to PEM with a password - it has to be at least four characters

      long.

    * SSL/TLS support for the Next Protocol Negotiation extension. Supported

      with OpenSSL 1.0.1 and higher.

    * OpenSSL::OPENSSL_FIPS allows client applications to detect whether OpenSSL

      is running in FIPS mode and to react to the

      situation (right.)

  * ostruct

    * new methods:

      * OpenStruct#each_pair

      * OpenStruct#eql?

      * OpenStruct#hash

      * OpenStruct#to_h converts the struct to a hash.

    * extended method:

      * OpenStruct.new also accepts an OpenStruct / Struct.

  * pathname

    * extended method:

      * Pathname#find returns an enumerator if no block is given.

  * rake

    * rake has been updated to version 0.9.5.

      This version is backwards-compatible with previous rake versions and

      contains many bug fixes.

      See

      http://rake.rubyforge.org/doc/release_notes/rake-0_9_5_rdoc.html for a list

      of changes in rake 0.9.3, 0.9.4 and 0.9.5.

  * rdoc

    * rdoc has been updated to version 4.0

      This version is largely backwards-compatible with previous rdoc versions.

      The most notable change is an update to the ri data format (ri data must

      be regenerated for gems shared across rdoc versions). Further API changes

      are internal and won't affect most users.

      See https://github.com/rdoc/rdoc/blob/master/History.rdoc for a list of

      changes in rdoc 4.0.

  * resolv

    * new methods:

      * Resolv::DNS#timeouts=

      * Resolv::DNS::Config#timeouts=

  * rexml

    * REXML::Document#write supports Hash arguments.

      * REXML::Document#write supports new :encoding option. It changes

        XML document encoding. Without :encoding option, encoding in

        XML declaration is used for XML document encoding.

  * RubyGems

    * Updated to 2.0.0.preview2

      RubyGems 2.0.0 features the following improvements:

      * Improved support for default gems shipping with ruby 2.0.0+

      * A gem can have arbitrary metadata through Gem::Specification#metadata

      * `gem search` now defaults to --remote and is anchored like gem list.

      * Added --document to replace --rdoc and --ri. Use --no-document to

        disable documentation, --document=rdoc to only generate rdoc.

      * Only ri-format documentation is generated by default.

      * `gem server` uses RDoc::Servlet from RDoc 4.0 to generate HTML

        documentation.

      For an expanded list of updates and bug fixes see:

      https://github.com/rubygems/rubygems/blob/master/History.txt

  * shellwords

    * Shellwords#shellescape() now stringifies the given object using to_s.

    * Shellwords#shelljoin() accepts non-string objects in the given

      array, each of which is stringified using to_s.

  * syslog

    * Added Syslog::Logger which provides a Logger API atop Syslog.

    * Syslog::Priority, Syslog::Level, Syslog::Option and Syslog::Macros

      are introduced for easy detection of available constants on a

      running system.

  * tmpdir

    * incompatible changes:

      * Dir.mktmpdir uses FileUtils.remove_entry instead of

        FileUtils.remove_entry_secure. This means that applications should not

        change the permission of the created temporary directory to make

        accessible from other users.

  * yaml

    * Syck has been removed. YAML now completely depends on libyaml being

      installed.

  * zlib

    * Added streaming support for Zlib::Inflate and Zlib::Deflate. This allows

      processing of a stream without the use of large amounts of memory.

    * Added support for the new deflate strategies Zlib::RLE and Zlib::FIXED.

    * Zlib streams are now processed without the GVL. This allows gzip, zlib and

      deflate streams to be processed in parallel.

=== Language changes

* Added %i and %I for symbol list creation (similar to %w and %W).

* Default source encoding is changed to UTF-8. (was US-ASCII)

=== Compatibility issues (excluding feature bug fixes)

* Array#values_at

  See above.

* String#lines

* String#chars

* String#codepoints

* String#bytes

  These methods no longer return an Enumerator, although passing a

  block is still supported for backwards compatibility.

  Code like str.lines.with_index(1) { |line, lineno| ... } no longer

  works because str.lines returns an array. Replace lines with

  each_line in such cases.

* Signal.trap

  See above.

* Merge Onigmo.

  https://github.com/k-takata/Onigmo

* The :close_others option is true by default for system() and exec().

  Also, the close-on-exec flag is set by default for all new file descriptors.

  This means file descriptors doesn't inherit to spawned process unless

  explicitly requested such as system(..., fd=>fd).

* Kernel#respond_to? against a protected method now returns false

  unless the second argument is true.

* Dir.mktmpdir in lib/tmpdir.rb

  See above.

* OpenStruct new methods can conflict with custom attributes named

  "each_pair", "eql?", "hash" or "to_h".

* Thread#join, Thread#value

  See above.

* Mutex#lock, Mutex#unlock, Mutex#try_lock, Mutex#synchronize and Mutex#sleep

  See above.

「Rubyは言語として2.0でほぼ完成」、まつもとゆきひろ氏が講演

2013/02/14
安東 一真＝日経Linux

記事一覧へ >>　いいね！ 108　ツイート 257

「Rubyはバージョン2.0で、言語としてほぼ完成した」――。東京・目黒雅叙園で2月15日まで開催している「Developers Summit 2013」で、Rubyの生みの親であるまつもとゆきひろ氏（**写真**）はこう宣言した。

Ruby 2.0は、Ruby生誕20周年を記念して、2013年2月24日にリリースする予定の新バージョン。まつもと氏は講演の中で、バージョン2.0の新機能を披露するとともに、

写真●まつもとゆきひろ氏
[画像のクリックで拡大表示]

“Ruby is almost matured as a programming language with 2.0 ”

http://itpro.nikkeibp.co.jp/article/NEWS/20130214/456322/

Ruby 2.1 release announcement

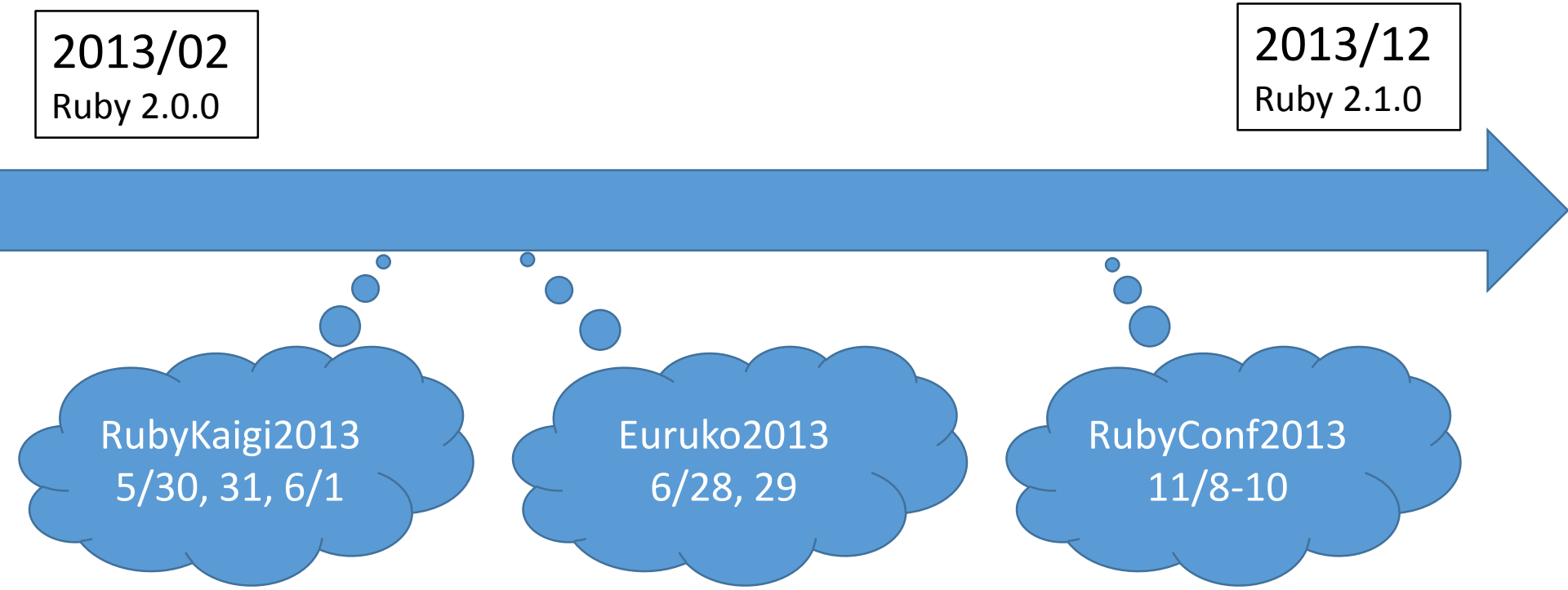
“I‘m planning to call for feature proposals soon like 2.0.0 [ruby-core:45474], so if you have a suggestion you should begin preparing the proposal.”

“ちなみに、Ruby 2.1.0 は2013年12月25日のリリースを予定しています。そのうち 2.0.0 の時のように機能提案募集をするつもりなので、われこそをという方はそろそろネタの仕込みを始めてくださいませ。”

- [ruby-core:54726] Announce take over the release manager of Ruby 2.1.0

by NARUSE, Yui

Ruby 2.1 schedule



Events are important for
EDD (Event Driven Development) Developers

Ruby 2.1

- New features

```
# -*- rdoc -*-

= NEWS for Ruby 2.1.0

This document is a list of user visible feature changes made between
releases except for bug fixes.

Note that each entry is kept so brief that no reason behind or
reference information is supplied with.  For a full list of changes
with all sufficient information, see the ChangeLog file.

== Changes since the 2.0.0 release

=== Language changes
=== Core classes updates (outstanding ones only)

* GC
  * added environment variable:
    * RUBY_HEAP_SLOTS_GROWTH_FACTOR: growth rate of the heap.

* IO
  * extended methods:
    * IO#seek accepts symbols (:CUR, :END, :SET) for 2nd argument.

* Kernel
  * New methods:
    * Kernel#singleton_method

* Mutex
  * misc
    * Mutex#owned? is no longer experimental.

* String
  * New methods:
    * String#scrub and String#scrub! verify and fix invalid byte sequence.
  * extended methods:
    * If invalid: :replace is specified for String#encode, replace
      invalid byte sequence even if the destination encoding equals to
      the source encoding.

* pack/unpack (Array/String)
  * Q! and q! directives for long long type if platform has the type.

=== Core classes compatibility issues (excluding feature bug fixes)

* IO
  * incompatible changes:
    * open ignore internal encoding if external encoding is ASCII-8BIT.

* Module#ancestors

  The ancestors of a singleton class now include singleton classes,
  in particular itself.

=== Stdlib updates (outstanding ones only)

* Digest
  * extended methods:
    * Digest::Class.file takes optional arguments for its constructor

* Matrix
  * Added Vector#cross_product.

* Net::SMTP
  * Added Net::SMTP#rset to implement the RSET command

* Pathname
  * New methods:
    * Pathname#write
    * Pathname#binwrite

* OpenSSL::BN
  * extended methods:
    * OpenSSL::BN.new allows Fixnum/Bignum argument.

* open-uri
  * Support multiple fields with same field name (like Set-Cookie).

* Resolv
  * New methods:
    * Resolv::DNS.fetch_resource
  * One-shot multicast DNS support
  * Support LOC resources

* Rinda::RingServer, Rinda::RingFinger
  * Rinda now supports multicast sockets.  See Rinda::RingServer and
    Rinda::RingFinger for details.

* Socket
  * New methods:
    * Socket.getifaddrs

* StringScanner
  * extended methods:
    * StringScanner#[] supports named captures.

* Tempfile
  * New methods:
    * Tempfile.create

=== Stdlib compatibility issues (excluding feature bug fixes)

* URI
  * incompatible changes:
    * URI.decode_www_form follows current WHATWG URL Standard.
      It gets encoding argument to specify the character encoding.
      It now allows loose percent encoded strings, but denies ; -separator.
    * URI.encode_www_form follows current WHATWG URL Standard.
      It gets encoding argument to convert before percent encode.
      UTF-16 strings aren't converted to UTF-8 before percent encode by default.

=== C API updates
```

See NEWS file

Now, much smaller than Ruby 2.0

Quoted “2.1”

“Character set and CES which application should support is different by users. However, it is not high priority to support one application supports multi-CES.”

- *Implementation of Practical Multilingual Text Manipulation for Ruby (academic paper)*

by Yukihiro Matsumoto

(translated by Koichi Sasada)

“アプリケーションが対応すべき文字集合およびCESはユーザごとに異なるが、1つのアプリケーションが同時に複数のCESに対応する必要性はさほど高くない。”

- Ruby における実用的な多言語処理の実装（論文）

松本 行弘

Ruby 2.1 features

- Refine m17n introduced from Ruby 1.9
  - String#scrub, String#scrub!
    - Verify and fix invalid byte sequence.
  - More efforts? I heard Matz has some ideas.

- Refine features introduced from Ruby 2.0
  - Keyword arguments
  - Refinements
  - Module#prepend

Quote about 2.0 from Heroku blog

heroku

How it Works | Pricing | Add-ons | Dev Ce

Blog

Matz on Ruby 2.0 at Heroku's Waza

by Craig - Mar 06

Matz, the creator of Ruby, spoke at Waza for the 20th anniversary of the language and the release of Ruby 2.0. If you weren't in the sold out crowd, not to worry. Information should flow free and experiences should be shared; in line with those concepts you can watch Matz's talk right here, then read about what's new in this version of Ruby and how to run it on Heroku.

*With slides available on **speakerdeck***

Running 2.0 on Heroku

If you're interested in taking advantage of these new features give it a try on Heroku today. To run Ruby 2.0 on Heroku you'll need this line in your `Gemfile`:

```
ruby "2.0.0"
```

Then commit to git:

```
$ git add .
$ git commit -m "Using Ruby 2.0 in production"
```

We recommend that you test your app using 2.0 locally and deploy to a staging app before pushing to production. Now when you `$ git push heroku master` our Ruby buildpack will see that you've declared your Ruby version and make sure you get the right one.

Of course, Ruby 2.0.0 is ready on Heroku!

20 years of simplicity, elegance, and programmer happiness

Heroku, since its founding, has been aligned with the key values of Ruby – simplicity, elegance, and programmer happiness. Heroku still believes in the power and flexibility of Ruby, and we've invested in the language by hiring **Yukihiro "Matz" Matsumoto**, **Koichi Sasada** and **Nobuyoshi Nakada**. We would like to thank them and the whole Ruby core team for making this release happen. Join us in celebrating Ruby's successes and in looking forward to the next twenty years by trying Ruby 2.0 on Heroku today.

Me!

Ruby apps are running using 1.8.7, you should upgrade. Ruby 1.8.7 is approaching End of Life (EOL) in three months on June 2013. EOL for Ruby 1.8.7 means no security or bug patches will be provided by the maintainers. Not upgrading means you're potentially opening up your application and your users to vulnerabilities. Don't wait till the final hour, upgrade now to be confident and secure.

Speed

Ruby 2.0 has a faster garbage collector and is **Copy on Write** friendly. Copy on Write or COW is an optimization that can reduce the memory footprint of a Ruby process when it is copied. Instead of allocating duplicate memory when a process is forked, COW allows multiple processes to share the same memory until one of the processes needs to modify a piece of information. Depending on the program, this optimization can dramatically reduce the amount of memory used to run multiple processes. Most Ruby programs are memory bound, so reducing your memory footprint with Ruby 2.0 may allow you to run more processes in fewer dynos.

*If you're not already running a concurrent backend consider trying the **Unicorn web server**.*

Features

In addition to running faster than 1.9.3, and having a smaller footprint, Ruby 2.0 has a number of new features added to the language including:

Mention about “Speed”

Ruby 2.0 has a faster **garbage collector** and is **Copy on Write** friendly.
that can reduce
when it is copie
memory when
processes to share the same memory until one of the processes needs to modify a piece of information. Depending on the program, this optimization can dramatically reduce the amount of memory used to run multiple processes. Most Ruby programs are memory bound, so reducing your memory footprint with Ruby 2.0 may allow you to run more processes in fewer dynos.

Short summary: GC uses bitmap marking and CoW friendly

If you’re not alrea
consider trying the Unicorn web server.

Short summary: Let’s try Unicorn!

(；°Д°)

Only mention about GC!!??
(I don’t work on GC)

。+.。ヽ(*>∀<*)ノ。.+。

Let’s consider about GC/memory management!

Ruby 2.1 internal features

- Internal hooks for memory management
- RGenGC: Restricted generational garbage collection

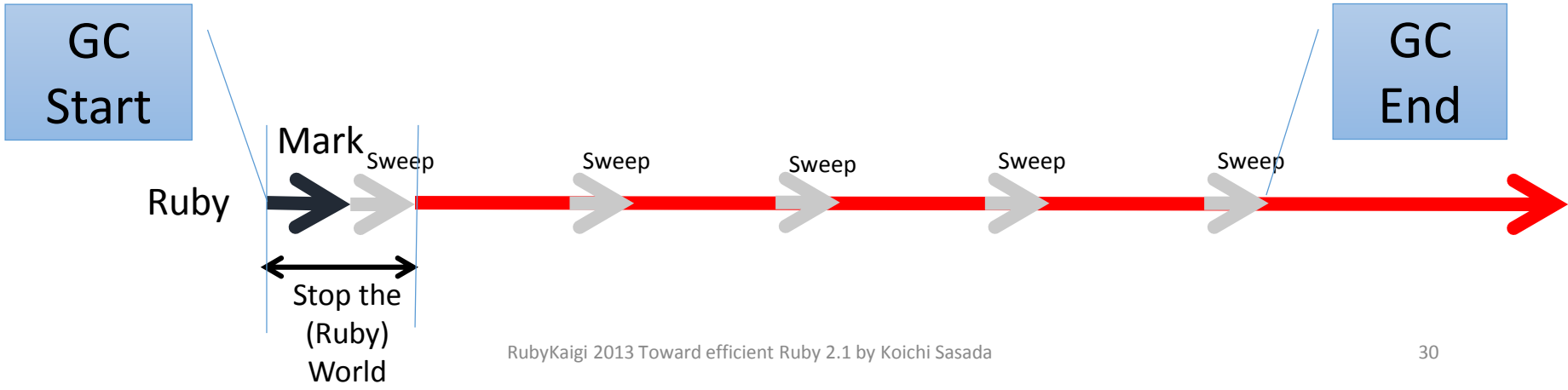
Today's topic

Internal hooks for memory management What's nice?

- You can collect more detailed analysis
- Examples
  - Collect object allocation site information
  - Collect usage of allocated objects
  - Measure GC performance from outside

Internal hooks for memory management

- Added events
  - RUBY_INTERNAL_EVENT_NEWOBJ
    - When object is created
  - RUBY_INTERNAL_EVENT_FREEOBJ
    - When object is freed
  - RUBY_INTERNAL_EVENT_GC_START
    - When GC is started
  - RUBY_INTERNAL_EVENT_GC_END
    - When GC is finished



Internal hooks for memory management *Caution*

- You can *NOT* trace these events using TracePoint (introduced from 2.0)
- You need to write C-ext to use them, because events are invoked during GC, etc

Internal hooks for memory management Sample features

- ObjectSpace. trace_object_allocations
  - Trace object allocation and record allocation-site
    - Record filename, line number, creator method's id and class
  - Usage:

```
ObjectSpace.trace_object_allocations{ # record only in the block
  o = Object.new
  file = ObjectSpace.allocation_sourcefile(o)   #=> __FILE__
  line = ObjectSpace.allocation_sourceline(o) #=> __LINE__ -2
}
```

  - Demonstration

Internal hooks for memory management Postponed job

- You may want to write hooks in Ruby

  → Use ‘Postponed job’
  - ‘Postponed jobs’ run at same timing as finalizers
  - Usage: rb_postponed_job_register(func, data)
  - `func(data)’ will be called at a safe-point

- See an sample code in “ext/objspace/gc_hooks.c”
  - ObjectSpace.after_gc_(start|end) = proc{GC.start}
  - Proc is called after GC

Quoted “2.1”

“2.1 Structure of VALUE and objects

In ruby, the contents of an object is expressed by a C structure, always handled via a pointer. A different kind of structure is used for each class, but the pointer type will always be VALUE.”

- Ruby Hacking Guide

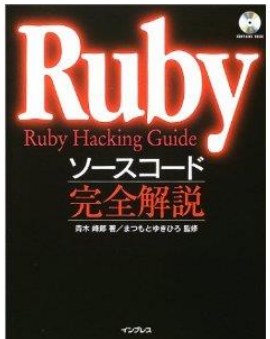
by Minero Aoki

“2.1 VALUEとオブジェクト構造体

rubyではオブジェクトの実体を構造体で表現し、扱うときは常にポインタ経由で扱う。構造体のほうはクラスごとに違う型を使うが、ポインタのほうはどのクラスの構造体でも常にVALUE型だ。“

- Rubyソースコード完全解説

青木峰郎



RGenGC: Summary

- RGenGC: Restricted Generational GC
  - New GC algorithm allows mixing “Write-barrier protected objects” and “WB unprotected objects”
  - **No** (mostly) **compatibility issue** with C-exts
- Inserting WBs gradually
  - We can concentrate WB insertion efforts for major objects and major methods
  - Now, **Array, String, Hash, Object, Numeric** objects are WB protected
    - Array, Hash, Object, String objects are very popular in Ruby
    - Array objects using **RARRAY_PTR() change to WB unprotected** objects (called as Shady objects), so existing codes still works.

RGenGC: Agenda

- Background
  - Generational GC
  - Ruby's GC strategy
- Proposal: RGenGC
  - Separating into sunny and shady objects
  - Shady objects at marking
  - Shade operation
- Implementation

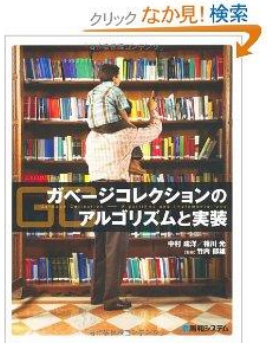
RGenGC: Background
Current CRuby's GC

- Mark & Sweep
  - Conservative
  - Lazy sweep
  - Bitmap marking
  - Non-recursive marking
- C-friendly strategy
  - Don't need magical macros in C source codes
  - Many many C-extensions under this strategy

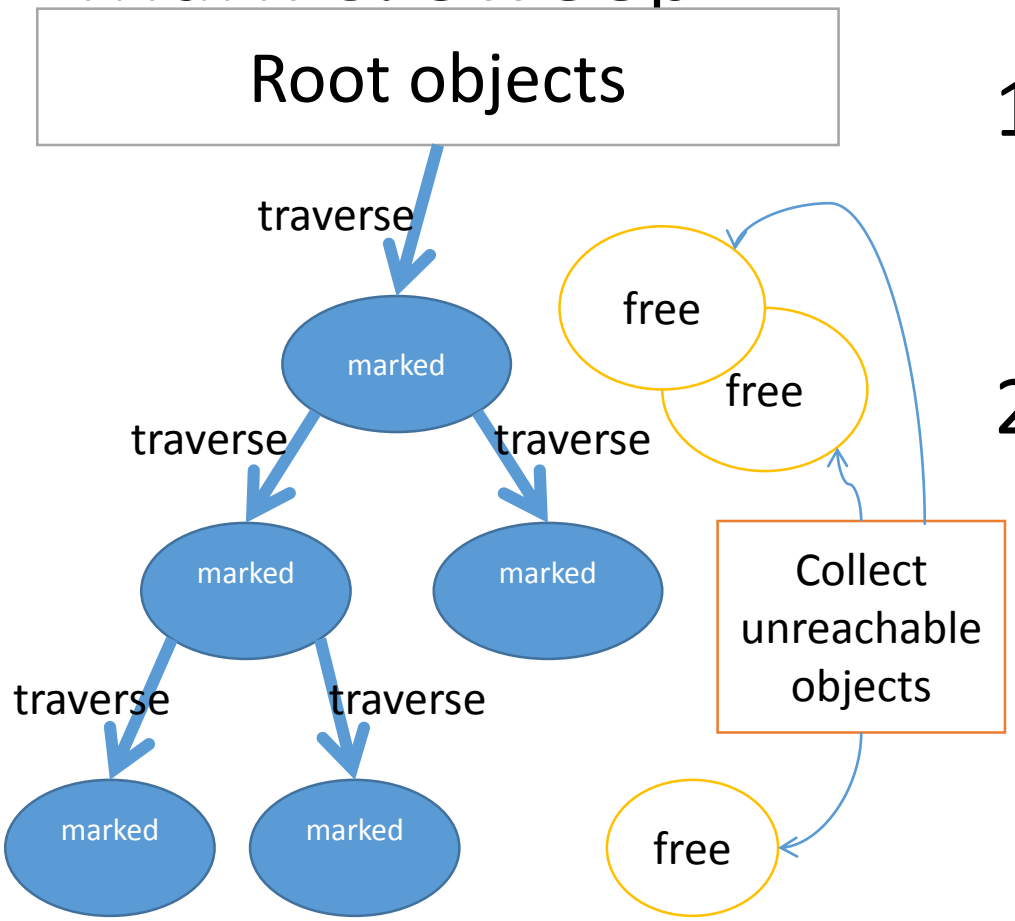
Quoted “2.1”

“2.1 About Mark&Sweep GC
Mark&Sweep GC consists of mark and sweep phase.”
- Garbage Collection-Algorithms and Implementations
By Narihiro Nakamura, Hikaru Aikawa
(translated by Koichi Sasada)

“2.1
マークスイープGCはその名の通り、マークフェーズとスイープフェーズから成ります。”
-ガベージコレクションのアルゴリズムと実装
By 中村成洋、相川光



RGenGC: Background Mark & Sweep



1. Mark reachable objects from root objects
2. Sweep ***unmarked*** objects (collection and de-allocation)

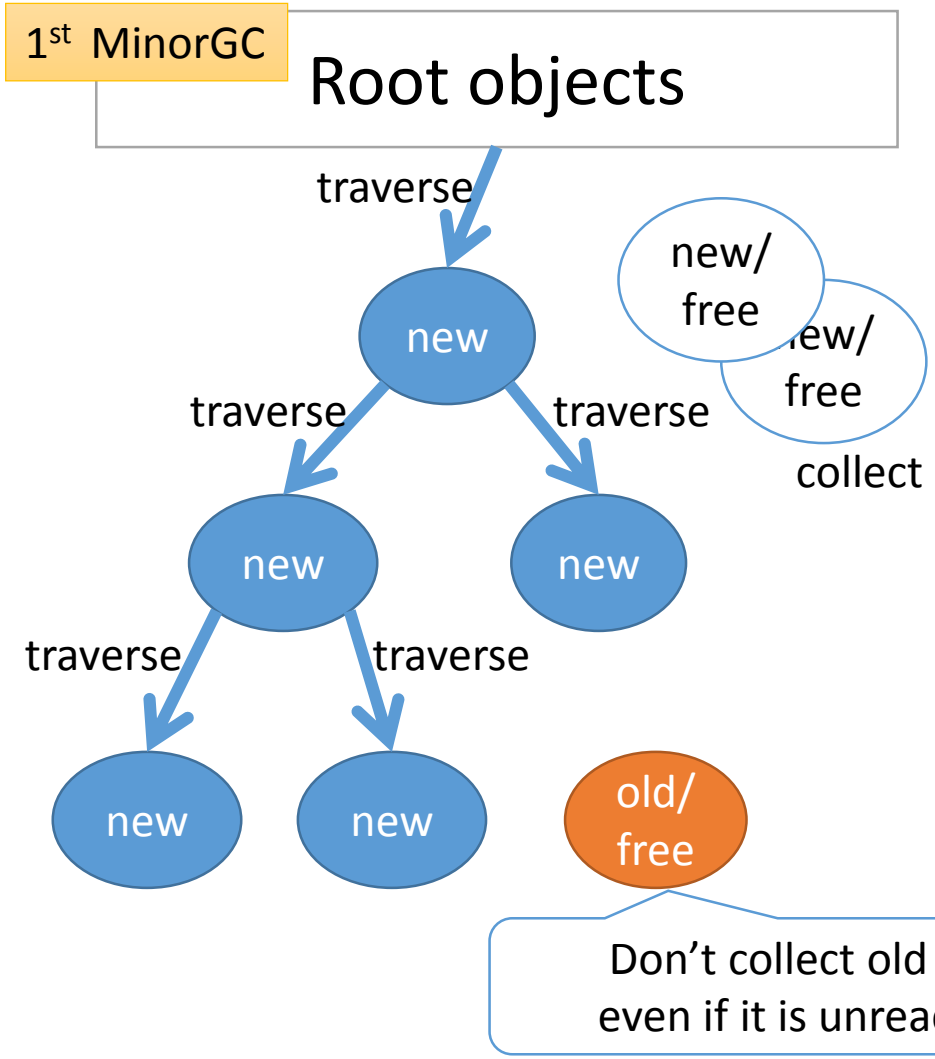
RGenGC: Background Generational GC (GenGC)

- Weak generational hypothesis: Most objects die young → Concentrating reclamation effort on the youngest objects
- Separate young generation and old generation
  - Create objects as young generation
  - Promote to old generation after surviving *nth* GC
  - In CRuby, *n == 1* (after 1 GC, objects become old)
- Usually, GC on young space (minor GC)
- GC on both spaces if no memory (major/full GC)

RGenGC: Background Generational GC (GenGC)

- Minor GC and Major GC can use different GC algorithm
  - Popular combination
    → Minor GC: Copy GC, Major GC: M&S
  - **On the CRuby's:** both **Minor&Major GCs should be M&S** because CRuby's GC (and existing codes) based on conservative M&S algorithm

RGenGC: Background: GenGC [Minor M&S GC]



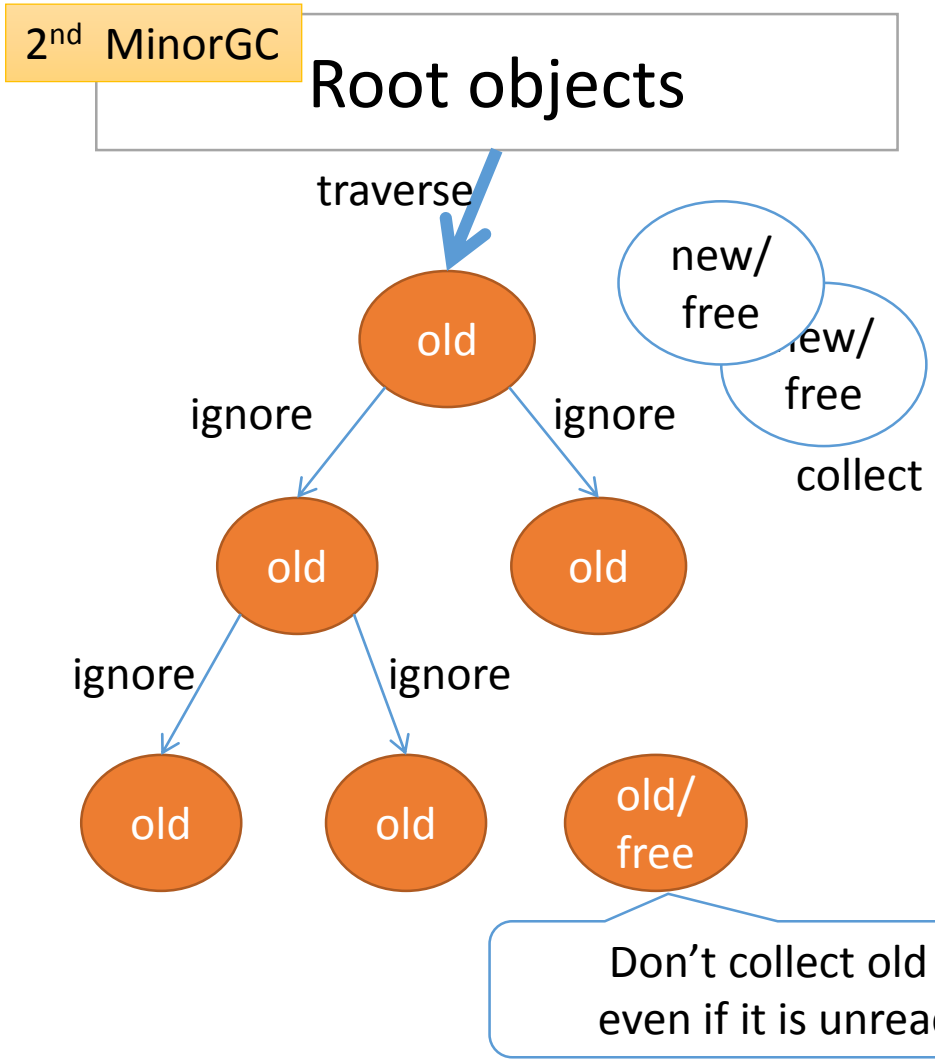
- Mark reachable objects from root objects.
  - Mark and **promote to old gen**
  - Stop traversing after old objects

→ Reduce mark overhead

- Sweep not (marked or old) objects

- Can't collect Some unreachable objects

RGenGC: Background: GenGC [Minor M&S GC]



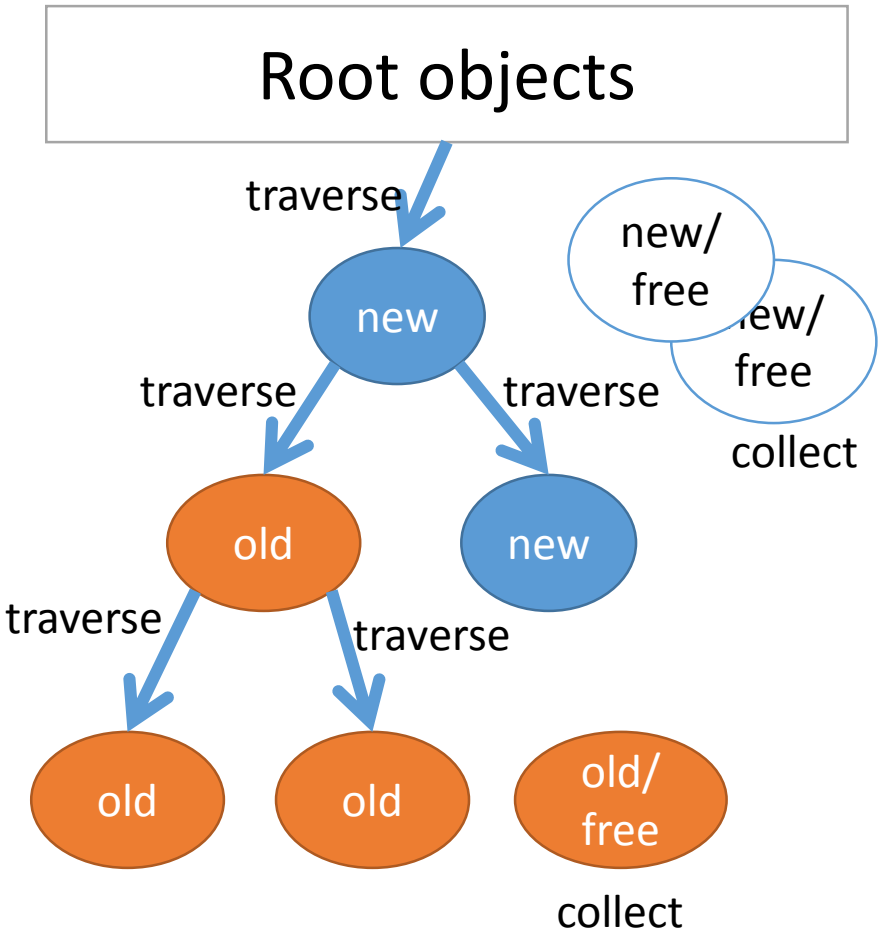
- Mark reachable objects from root objects.
  - Mark and **promote to old gen**
  - Stop traversing after old objects

→ Reduce mark overhead

- Sweep not (marked or old) objects

- Can't collect Some unreachable objects

RGenGC: Background: GenGC [Major M&S GC]



- Normal M&S
- Mark reachable objects from root objects
  - Mark and **promote to old gen**
- Sweep unmarked objects

- *Sweep all unreachable (unused) objects*

Quoted “2.1”

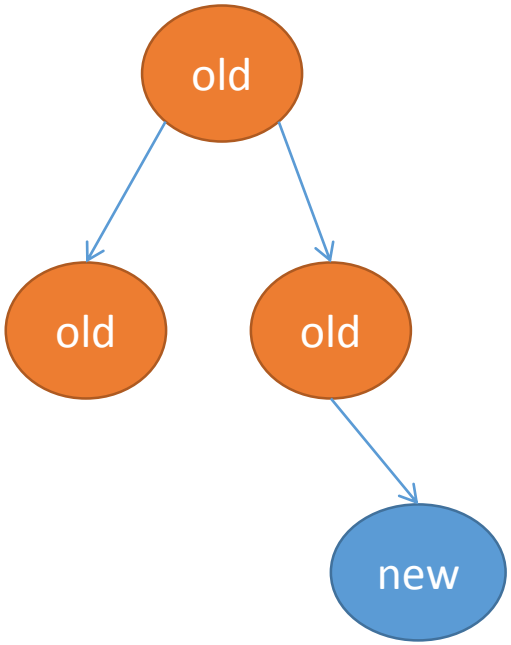
“2.1 The mark-sweep algorithm

From the viewpoint of the garbage collector, mutator threads perform just three operations of interest, New, Read and Write, which each collection algorithm must redefine appropriately.”

- The Garbage Collection Handbook

by Richard Jones, Antony Hosking, Eliot Moss

RGenGC: Background: GenGC WB & Remember Set (RSet)



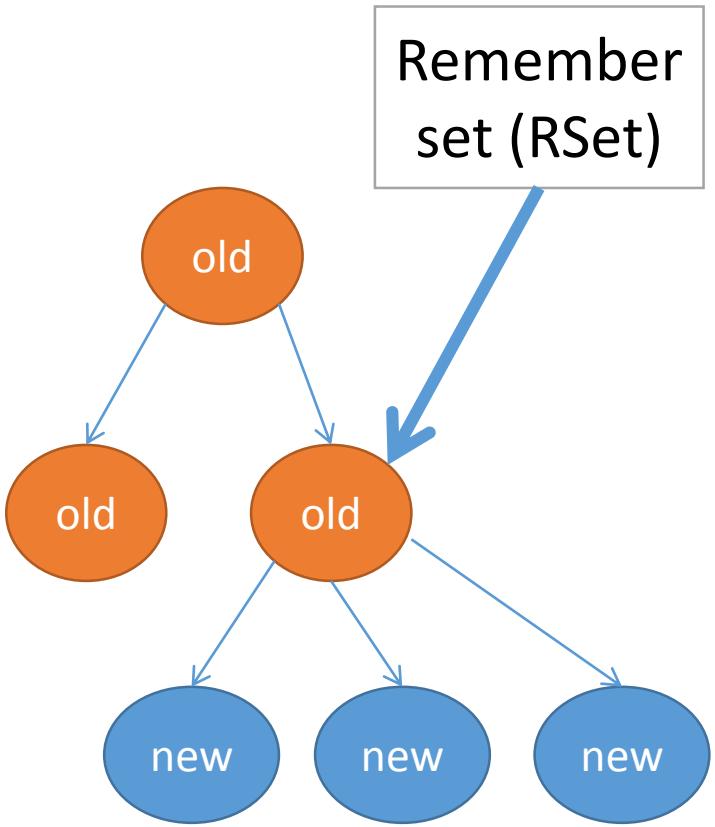
Can't mark new object!
→ Sweeping living object! (BUG)

- Old objects refer young objects

→ Minor GC causes marking leak!!

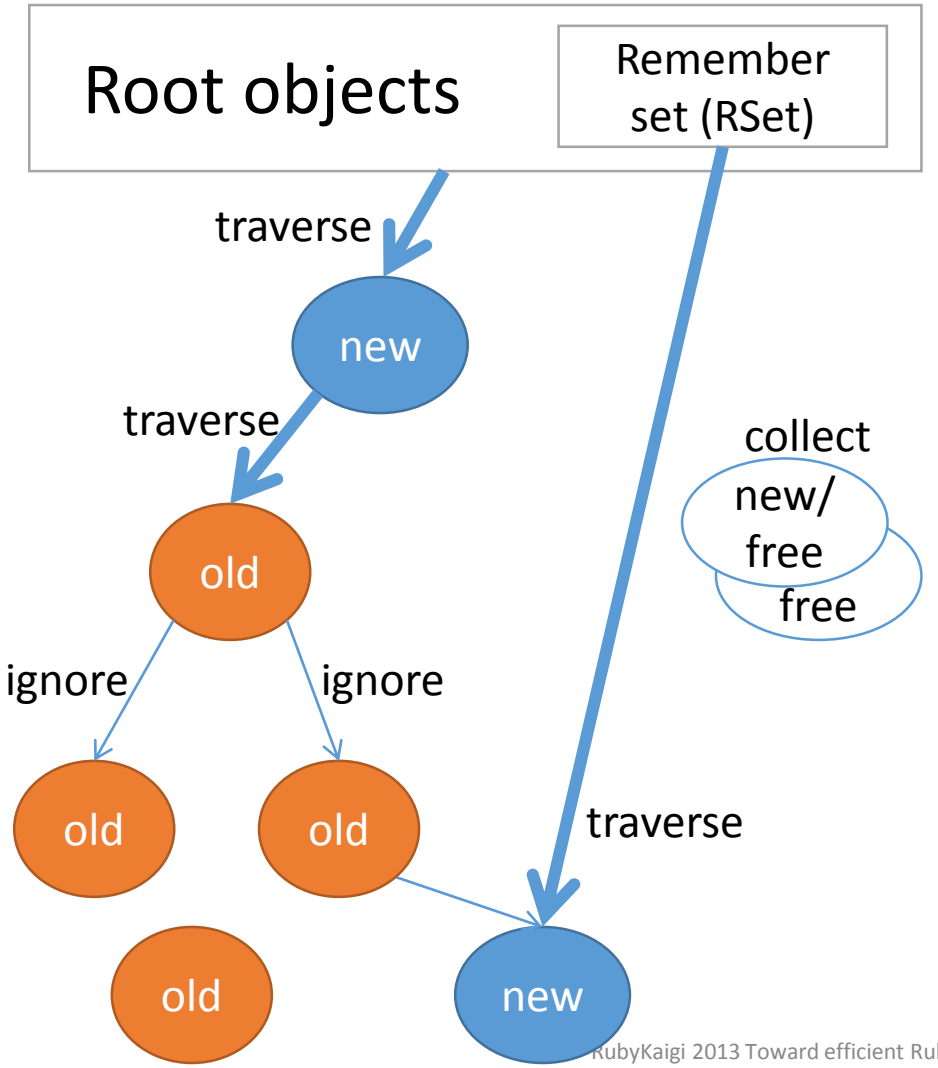
  - Because minor GC ignores referenced objects by old objects

RGenGC: Background: GenGC WB & Remember Set (RSet)



- Add an old object into **Remember set (RSet)** if an old object refer new objects
  - At minor GC, mark all remembered objects
- To detect [old→new] type references, insert **"Write-barrier"**
  - "Generating references" == "Write"

RGenGC: Background: GenGC [Minor M&S GC] w/ RSet



- Mark reachable objects from root objects
  - **Remembered objects are also root objects**
- Stop traversing after old objects
- Sweep not (marked or old) objects

RGenGC: Problem Write-barrier (WB) and CRuby

- To introduce generational garbage collector, WBs are necessary to detect [old→new] type reference
- Write-barrier (WB) example in Ruby world
  - (Ruby) old0[0] = new0 # [old0 → new0]
  - (Ruby) old1.foo = new0 # [old1 → new1]
- Write-barriers miss causes terrible failure
  - WB miss

    → Remember-set registration miss

    → (minor GC) marking-miss → **Terrible GC BUG!!**
- All of C-extensions need perfect Write-barriers
  - Manipulate Ruby objects in C language (in C-ext)
  - C-level WBs are needed

RGenGC: Problem
Inserting WBs into C-extensions (C-ext)

- **Problem: Compatibility**
  - Example (C) RARRAY_PTR(old0)[0] = new1
  - There are **Many Many** C-exts' sources like that
- CRuby core code uses C-APIs, but we can rewrite all of source code (with terrible debugging!!)
- We can't rewrite all of C-exts which are written by 3rd party

RGenGC: Problem
Inserting WBs into C-extensions (C-ext)

"Two options"

[Give up on GenGC]

Current Choice

or

[GenGC with re-writing all of C-extensions without C-exts compatibility]

RGenGC: Related work on Ruby's GenGC

- Kiyama, et. al. GenGC for CRuby
  - Straightforward implementation for Ruby 1.6
  - Need WBs in correct places
  - High development cost
  - Can't keep compatibility → Drop all C-exts
- Nari, et.al longlife GC for CRuby
  - Introduce GenGC only for Node object
  - No compatibility issues because C-exts don't use node
  - Now CRuby doesn't use many number of node objects
  - High development cost (to guarantee WBs)

RGenGC:
Related work on Ruby's GenGC

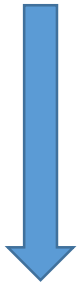
- Make interpreter with other language infrastructures which have GC
  - JRuby, IronRuby
  - Can't keep compatibility with current C-exts
- Separate core heap and CRuby C-ext heap
  - High development cost

RGenGC: Challenge

- How to insert Write-barriers?
  - In Ruby-core, we can chnage w/ huge effort
  - However, we can't touch existing C-exts ← Problem
- Several approaches
  - Separate heaps into the WB world and non-WB world
    - Need to re-write whole of Ruby interpreter
    - Need huge development effort
  - WB auto-insertion
    - Modify C-compiler
    - Need huge development effort

RGenGC:
Challenge to introduce GenGC

- **Create GC algorithm permits WB protected objects AND WB un-protected object in the same heap**



RGenGC: Restricted Generational Garbage Collection

RGenGC: Goal
Inserting WBs into C-extensions (C-ext)

"2 → 3 options"

[Give up on GenGC]

or

[GenGC with re-writing all of C-extensions without C-exts compatibility]

or

[Use RGenGC]

New choice!!

RGenGC: Key idea

- Introduce **Shady object**
  - In this context, “Shady” means questionable, doubtful, etc
  - Something feeling dark
  - 日陰者, in Japanese

Google image search: “日陰者”

RGenGC:
Key Idea

- Separate objects into two types
  - Shady Object: WB Unprotected
  - Sunny Object: WB Protected

Shady: doubtful, questionable, ...

An antonym of the word “Shady”

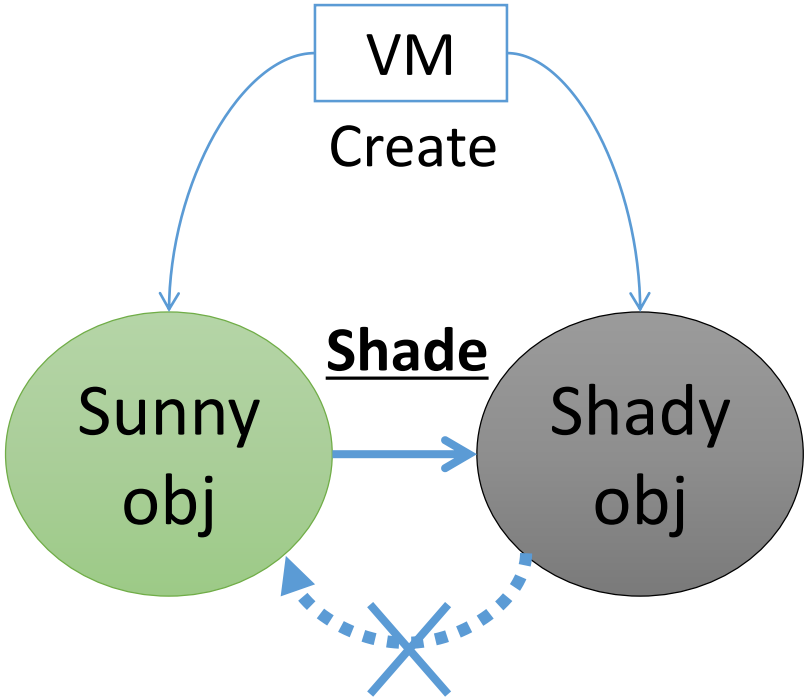
Shady
(´･ω･`)

Sunny
＼(^o^)／

- Decide this type at creation time
  - A class don’t care about WB → Shady obj
  - A class care about WB → Sunny obj
  - Currently, most of classes **DON’t** care about WB, so **most of objects are created as Shady objects.**

RGenGC:
Key Idea

- Sunny objects can change to Shady objects
  - "Shade" operation
  - In the C program doesn't care about RGenGC
  - Example
    - ptr = RARRAY_PTR(ary)
    - In this case, we can't insert WB for ptr operation, so VM shade "ary"

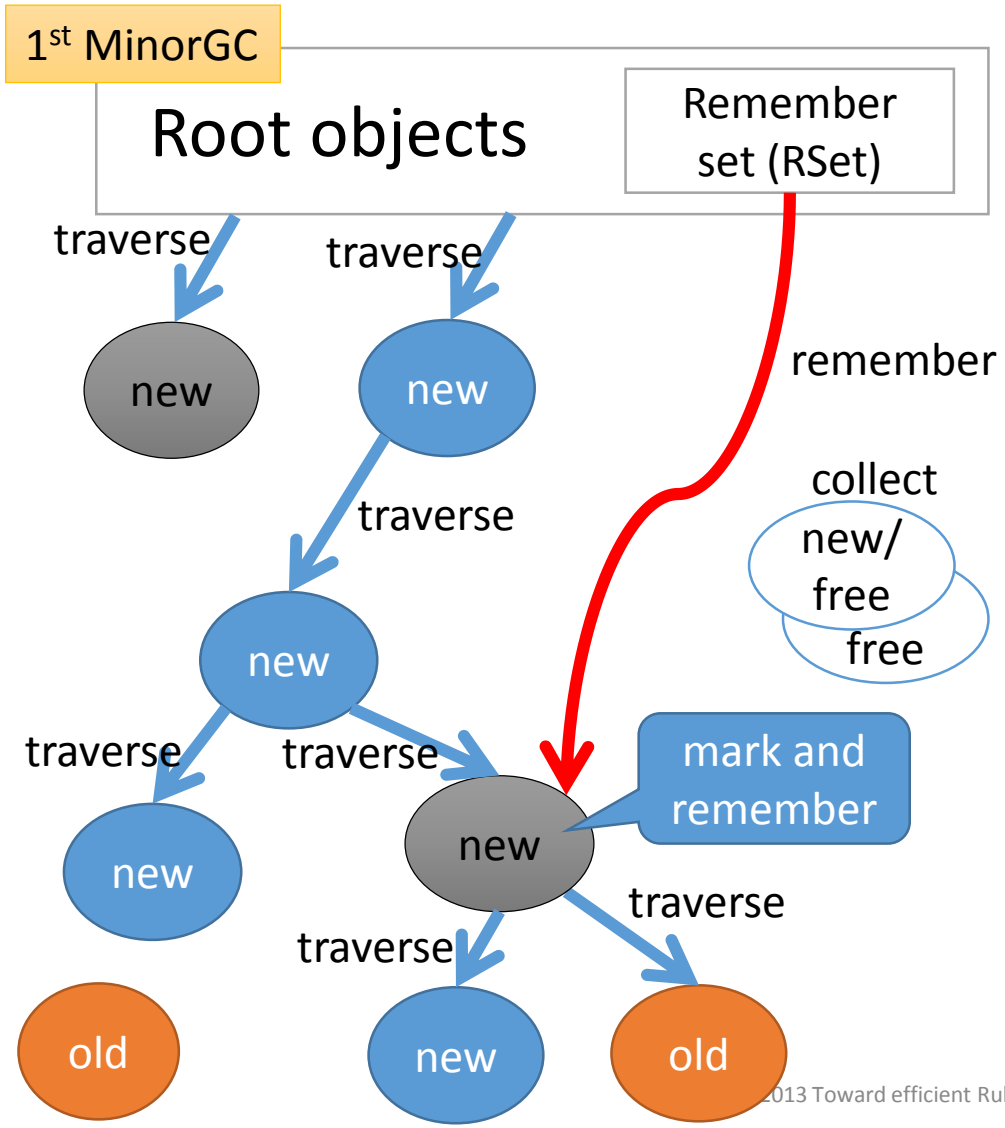


Shady object **can't** change into sunny object

RGenGC
Key Idea: Rule

- Mark “Shady objects” correctly
  - At Marking
    1. Don’t promote shady objects to old objects
    2. Remember shady objects pointed from old objects
  - At Shade operation for old sunny objects
    1. Demote objects
    2. Remember shaded shady objects

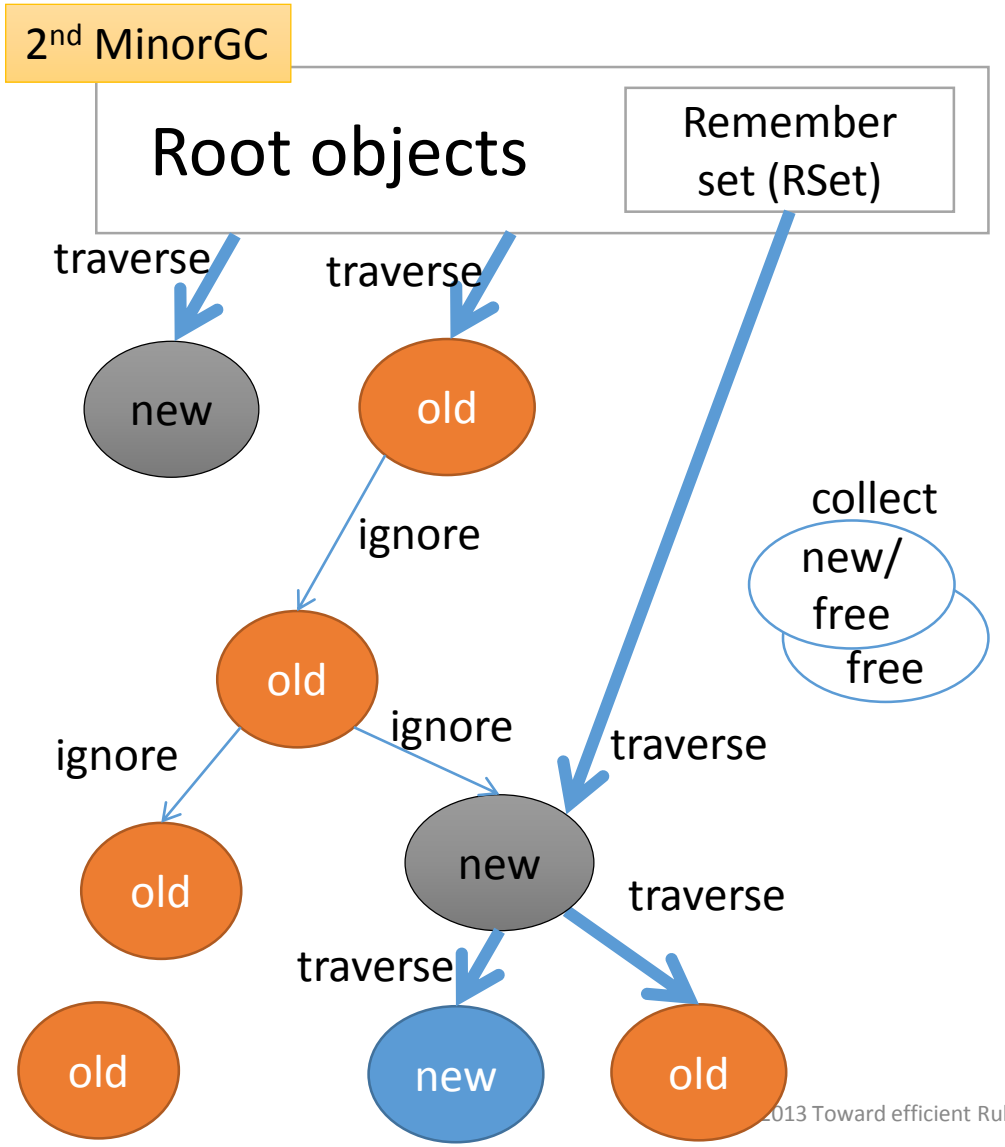
RGenGC
[Minor M&S GC w/Shady object]



- Mark reachable objects from root objects
  - Mark shady objects, and ***don't promote*** to old gen objects
  - If shady objects **pointed from old objects**, then **remember shady objects** by RSet.

    → Mark shady objects every minor GC!!

RGenGC
[Minor M&S GC w/Shady object]



- Mark reachable objects from root objects
  - Mark shady objects, and ***don't promote**** to old gen objects
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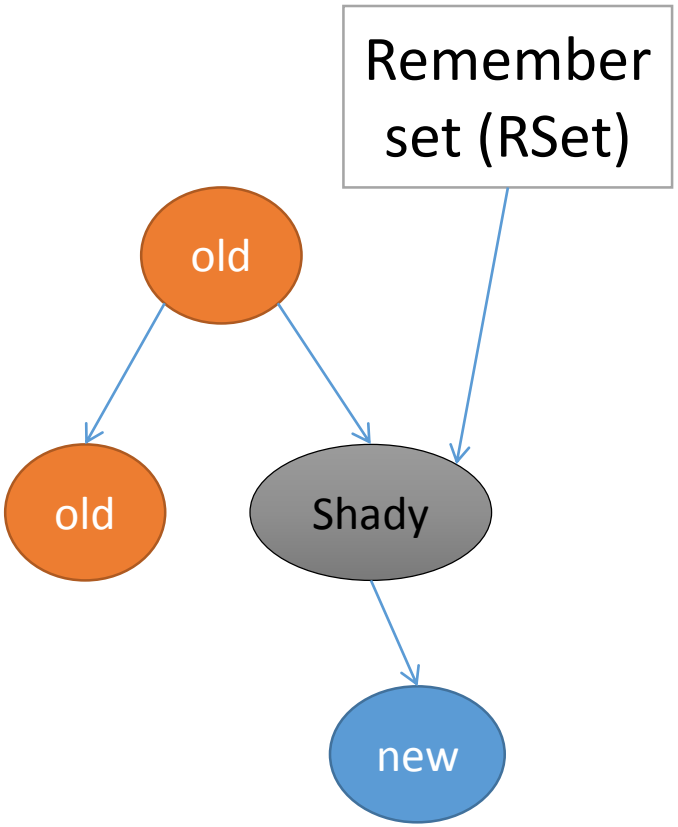
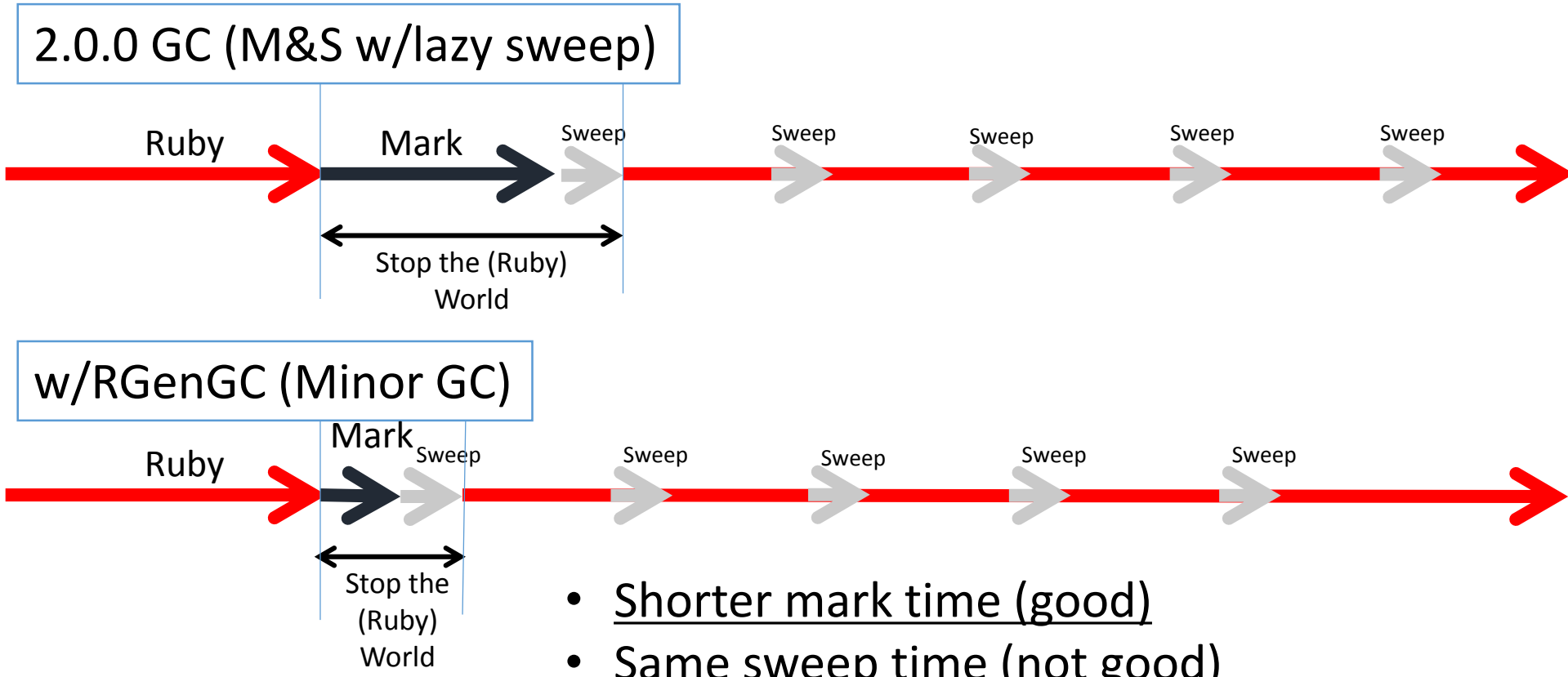
    → Mark shady objects every minor GC!!

RGenGC
[Shade operation]



- Old sunny objects → Shade objects
  - Example: RARRAY_PTR(ary)
  - (1) Demote object (old → new)
  - (2) Register it to Remember Set

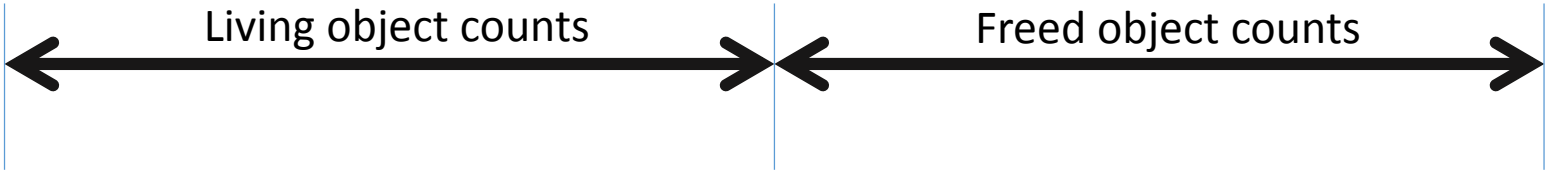
RGenGC Timing chart



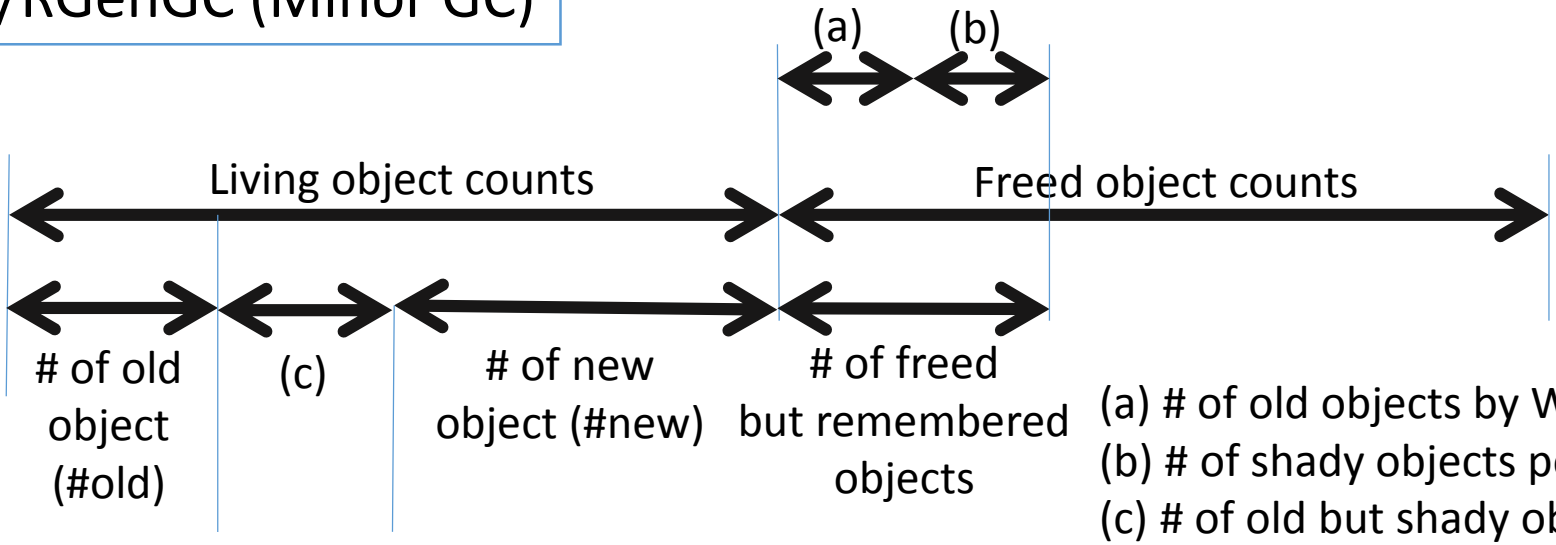
- Shorter mark time (good)
- Same sweep time (not good)
- (little) Longer execution time b/c WB (bad)

RGenGC
Number of marking objects

2.0.0 GC (M&S w/lazy sweep)



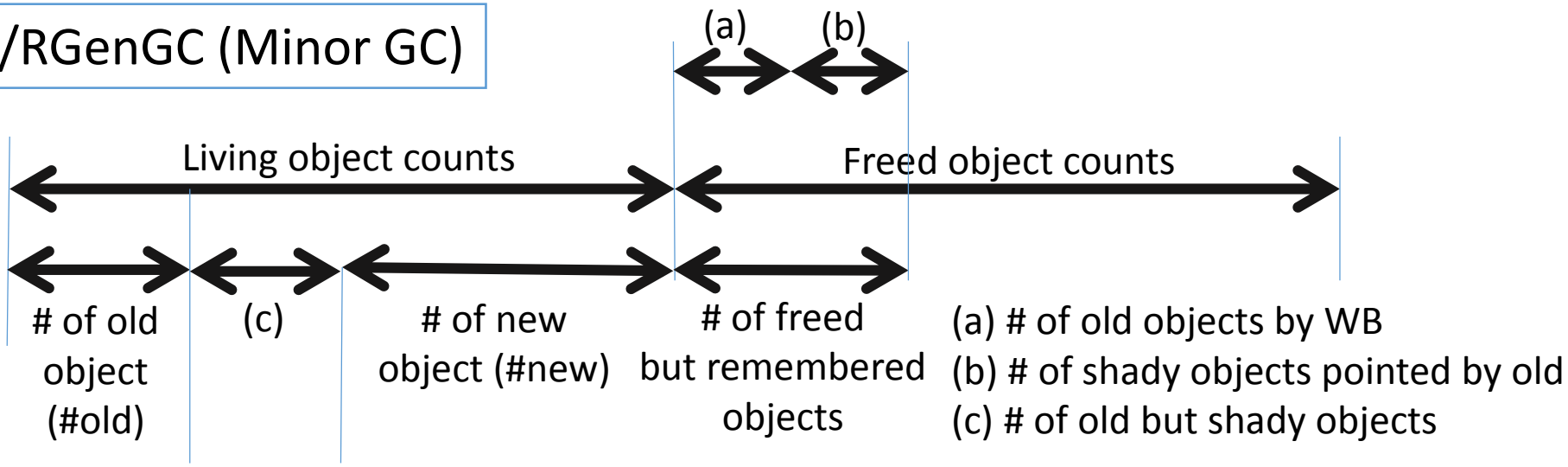
w/RGenGC (Minor GC)



(a) # of old objects by WB
(b) # of shady objects pointed by old
(c) # of old but shady objects

RGenGC
Number of marking objects

w/RGenGC (Minor GC)



	Marking space	Number of unused, uncollected objs	Sweeping space
Traditional GenGC	#new + (a)	(a)	#new
RGenGC	#new + (a) + (b) + (c)	(a) + (b)	Full heap

RGenGC Discussion: Pros. and Cons.

- Pros.
  - Allow WB unprotected objects (shady objects)
    - **100% compatible** w/ existing extensions (and standard classes/methods)
  - **Inserting WBs step by step, and increase performance gradually**
    - We don't need to insert all WBs into interpreter core at a time
    - We can concentrate into popular (frequent) classes/methods.
    - We can ignore minor classes/methods.
  - Simple algorithm, easy to develop (done!)

RGenGC
Discussion: Pros. and Cons.

- Cons.
  - Increasing “unused, but not corrected objects until full/major GC
    - Remembered objects (caused by well known GenGC algorithm)
    - Remembered shady objects (caused by RGenGC algorithm)
  - WB insertion (potential) bugs
    - RGenGC permit shady objects, but sunny objects need correct/perfect WBs. But inserting correct/perfect WBs is difficult.
    - This issue is out of scope. We have another idea against this problem (out of scope).
  - Can’t reduce Sweeping time
    - But many (and easy) well-known techniques to reduce sweeping time (out of scope).

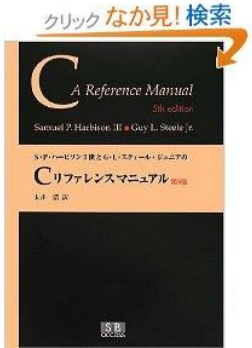
Quoted “2.1”

“2.1 Character set
…”

- C Reference manual
By Samuel P. Harbison III, Guy L.Steele Jr.

“2.1 文字集合
一つのCソースファイルは、一つの文字集合に含まれる文字の並びである。”

-C リファレンスマニュアル

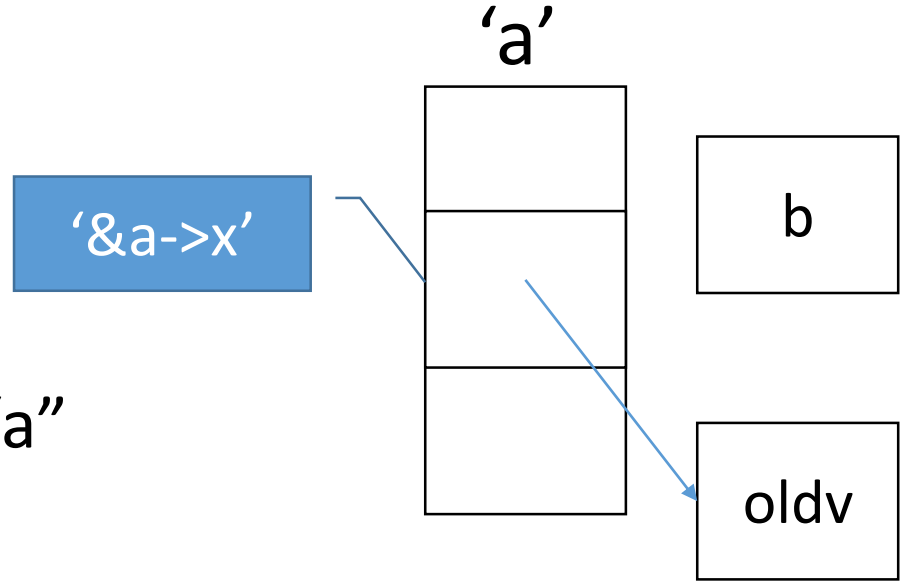


RGenGC Implementation

- Introduce two flags into RBasic
  - FL_KEEP_WB: WB protected or not protected
    - 0 → unprotected → Shady object
    - 1 → protected → Sunny object
    - Usage: NEWOBJ_OF(ary, struct RArray, klass, T_ARRAY | **FL_KEEP_WB**);
  - FL_OLDGEN: Young gen or Old gen?
    - 0 → Young gen
    - 1 → Old gen
    - Don’t need to touch by user program
- Remember set is represented by bitmaps
  - Same as marking bitmap
  - heap_slot::rememberset_bits
  - Traverse all object area with this bitmap at first

RGenGC Implementation: WB operation API

- OBJ_WRITE(a, &a->x, b)
  - Declare ‘a’ aggregates ‘b’
  - **Write:** *&a->x = b
  - Write barrier
  - OBJ_WRITE(a, b) returns “a”



- OBJ_WRITTEN(a, oldv, b)
  - Declare ‘a’ aggregates ‘b’ and old value is ‘oldv’
  - Non-write operation
  - Write barrier

RGenGC Implementation: WB operation API

- T_ARRAY
  - **RARRAY_PTR(ary) causes shade operation**
    - Can't get RGenGC performance improvement
    - But works well ☺
- Instead of RARRAY_PTR(ary), use alternatives
  - **RARRAY_AREF(ary, n)** → RARRAY_PTR(ary)[n]
  - **RARRAY_ASET(ary, n, obj)** → RARRAY_PTR(ary)[n] = obj w/ Write-barrier
  - **RARRAY_PTR_USE(ary, ptrname, {...block...})**
    - Only in block, pointers can be accessed by `ptrname' variable (VALUE*).
    - **Programmers need to insert collect WBs (miss causes BUG)**.

RGenGC Incompatibility

- Make RBasic::klass “const”
  - Need WBs for a reference from an object to a klass.
  - Only few cases (zero-clear and restore it)
  - Provide alternative APIs
    - Now, RBASIC_SET_CLASS(obj, klass) and RBASIC_CLEAR_CLASS(obj) is added. But they should be internal APIs (removed soon).
    - rb_obj_hide() and rb_obj_reveal() is provided.

RGenGC Implementation

- RGENGC_CHECK_MODE in gc.c
  - 1: Enable assertions
  - 2: Enable “WB checking” mode
- WB checking mode
  - (1) do minor GC
  - (2) do major/full GC
  - (3) compare result with (1) and (2)
    - If living objects in (2) but not living in (1) it should be BUG!!
  - Not a perfect (implementation limitation), but a good method to detect bugs

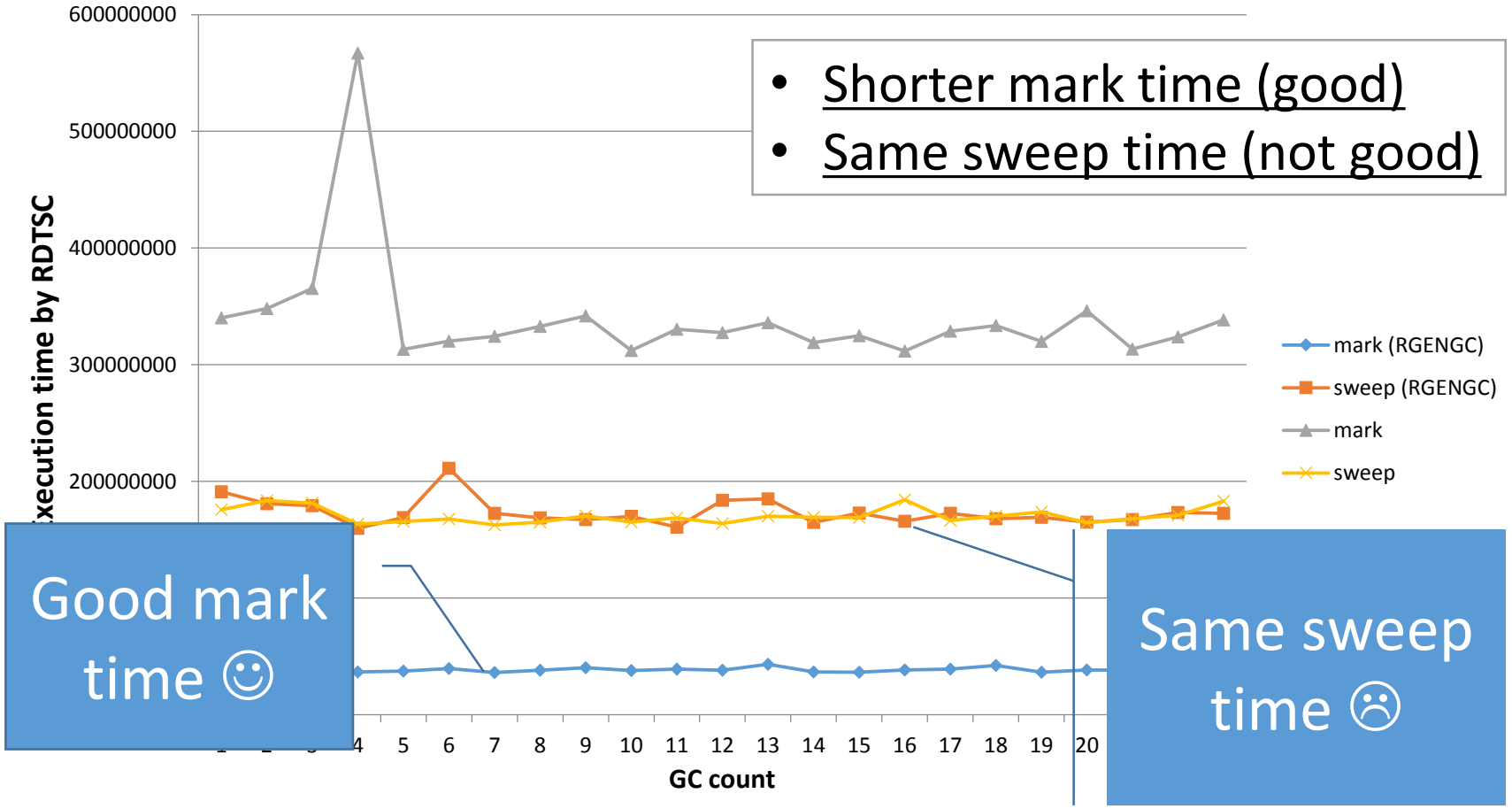
RGenGC Implementation

- Macros in ruby/ruby.h
  - USE_RGENGC
    - You can enable/disable RGenGC with this macro.
  - RGENGC_WB_PROTECTED_???
    - RGENGC_WB_PROTECTED_ARRAY, RGENGC_WB_PROTECTED_HASH, RGENGC_WB_PROTECTED_STRING, RGENGC_WB_PROTECTED_OBJECT, RGENGC_WB_PROTECTED_FLOAT, RGENGC_WB_PROTECTED_COMPLEX, RGENGC_WB_PROTECTED_RATIONAL, RGENGC_WB_PROTECTED_BIGNUM
    - Now, only supports above types (T_???).
      - T_CLASS, T_MODULE and T_DATA is needed to support with high priority.
    - You can enable/disable RGenGC for each types.
  - If you have trouble with RGenGC, try to disable them.

RGenGC
Performance evaluation

- Ideal micro-benchmark for RGenGC
  - Create many old objects at first
  - Many new objects (many minor GC, no major GC)
- RDoc
  - Same RDoc generation as Ruby's trunk

RGenGC
Performance evaluation (micro)

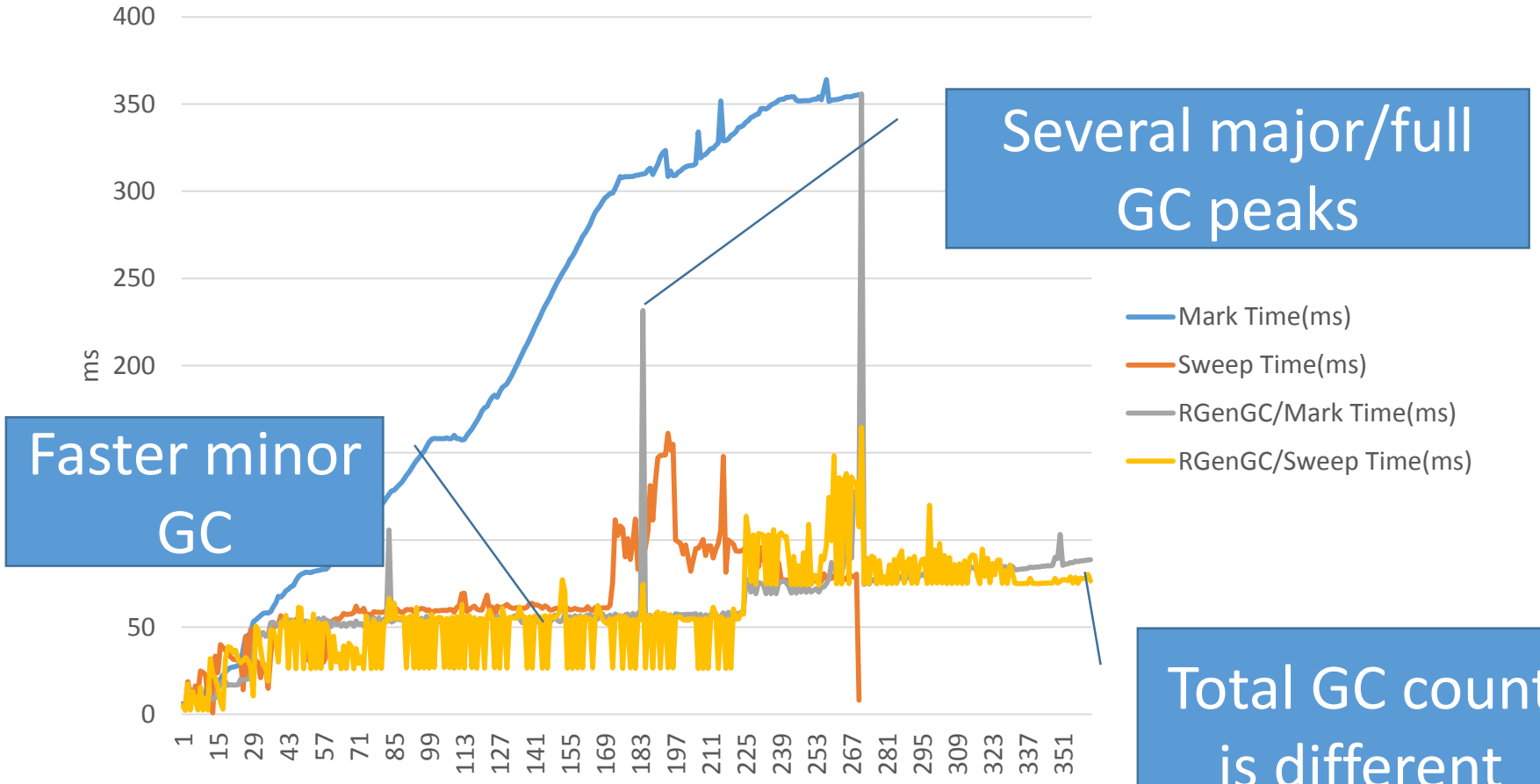


- Shorter mark time (good)
- Same sweep time (not good)

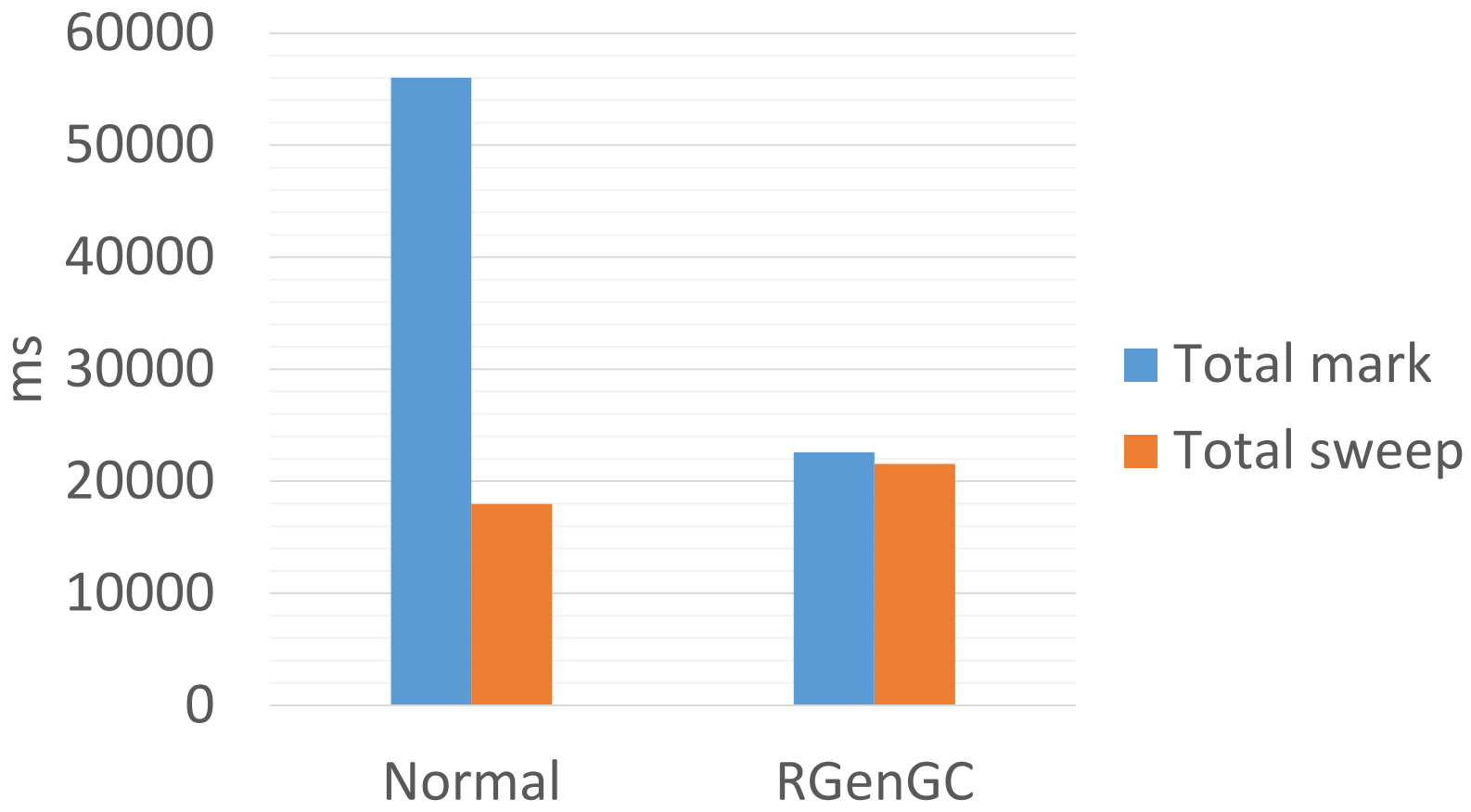
Good mark time ☺

Same sweep time ☹

RGenGC
Performance evaluation (RDoc)



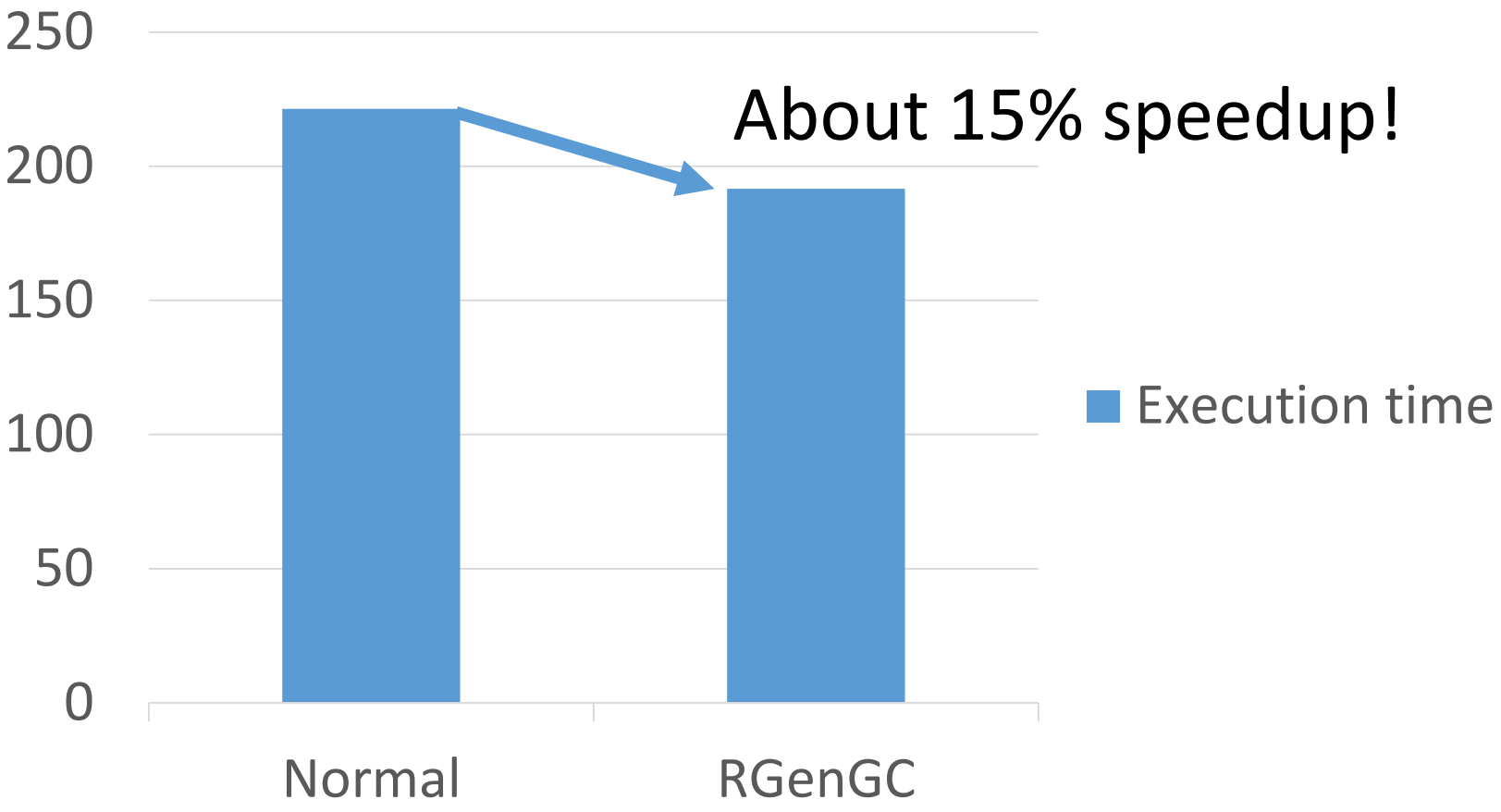
RGenGC
Performance evaluation (RDoc)



RGenGC
Performance evaluation (RDoc)

Of course, this is “Graph magic”.
If a students submits this graph, his score is fail.

RGenGC
Performance evaluation (RDoc)



RGenGC: Summary

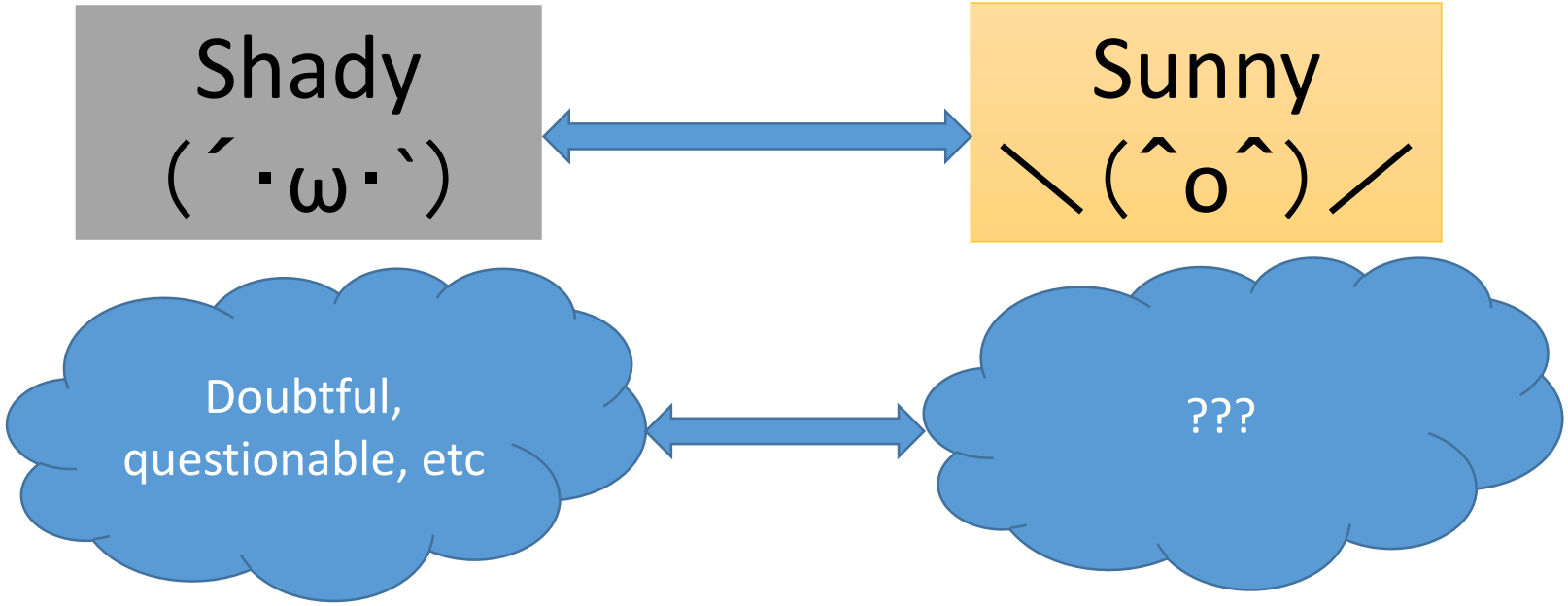
- RGenGC: Restricted Generational GC
  - New GC algorithm allow mixing “Write-barrier protected objects” and “WB unprotected objects”
  - **No** (mostly) **compatibility issue** with C-exts
- Inserting WBs gradually
  - We can concentrate WB insertion efforts for major objects and major methods
  - Now, **Array** and **String** objects are WB protected
    - Array and String objects are very popular in Ruby
    - Array objects using **RARRAY_PTR() change to WB unprotected** objects (called as Shady objects), so existing codes work well

RGenGC
Future work

- Minor GC / Major GC timing
  - Too many major GC → slow down
  - Too few major GC → memory consumption issue, etc
- Make more sunny objects (especially T_CLASS)
- Optimize remember set representation
- Inserting WBs w/ application profiling
  - Profiling system
  - Benchmark programs
- Detection system for WBs insertion miss
  - RGENGC_CHECK_MODE (2, in gc.c) is not enough

RGenGC
Issues: Terminology

- **Matz rejected the word “Sunny”**
- “Shady” has a meaning of “questionable, doubtful, …”, but “Sunny” has no meaning of against “questionable, doubtful, etc”.



RGenGC
Issues: Terminology

- This is a last presentation to use “Shady” and “Sunny”
- We will replace codes and documents with:
  - “Shady” → “WB unprotected”
  - “Sunny” → “WB protected”
- Or
  - “Shady” → “Shady” (remain)
  - “Sunny” → “Normal” (not shady)

If you have any idea of the words, please let us know.

Quoted “2.1”

“2:1 Now when Jesus was born in Bethlehem of Judaea in the days of Herod the king, behold, there came wise men from the east to Jerusalem,”

- Gospel of Matthew

“2:1 イエスがヘロデ王の代に、ユダヤのベツレヘムでお生れになったとき、見よ、東からきた博士たちがエルサレムに着いて言った、”

- マタイによる福音書

Ruby 2.1 expected “internal” features

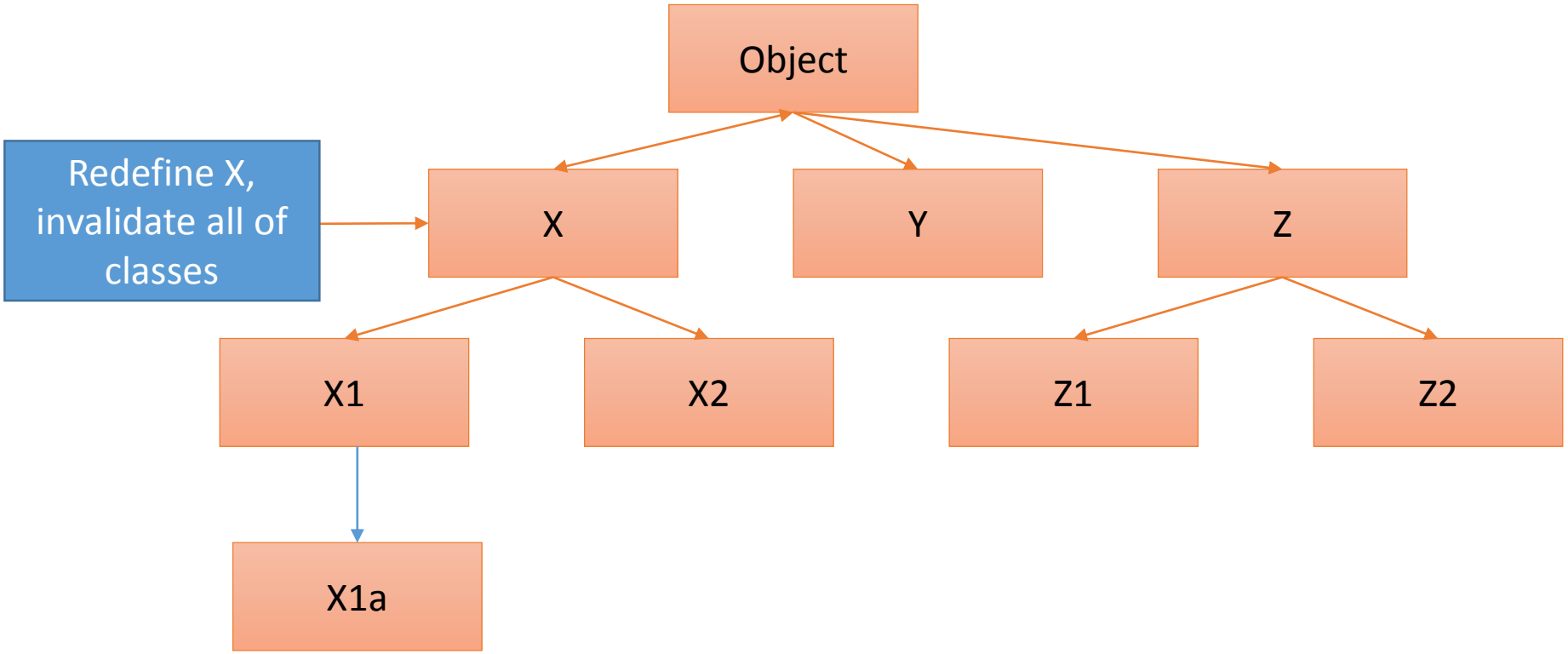
- Sophisticated inline cache invalidation mechanism
- Memory efficient string management & Symbol GC
- Fine-grain memory protection to detect WB insertion miss
- Signal thread
- More efficient inter-process migration technique
- JIT compilation for small part of Ruby code
- Introduce fastpath C-methods type
- Inlined Proc.call invocation
- AOT Compiler and extending “require” behavior
- Useful debugger

Sophisticated inline cache invalidation mechanism

- From Ruby 1.9 (YARV), inline cache technique is used in several codes
  - Inline method caching ← Huge opportunity
  - Constant lookup
  - …
- Cache invalidation with only one variable "global_state_version"
- Invalidate inline cache, other non-related inline caches are also invalidated

Sophisticated inline cache invalidation mechanism

- Invalidate all classes' method cache



Sophisticated inline cache invalidation mechanism

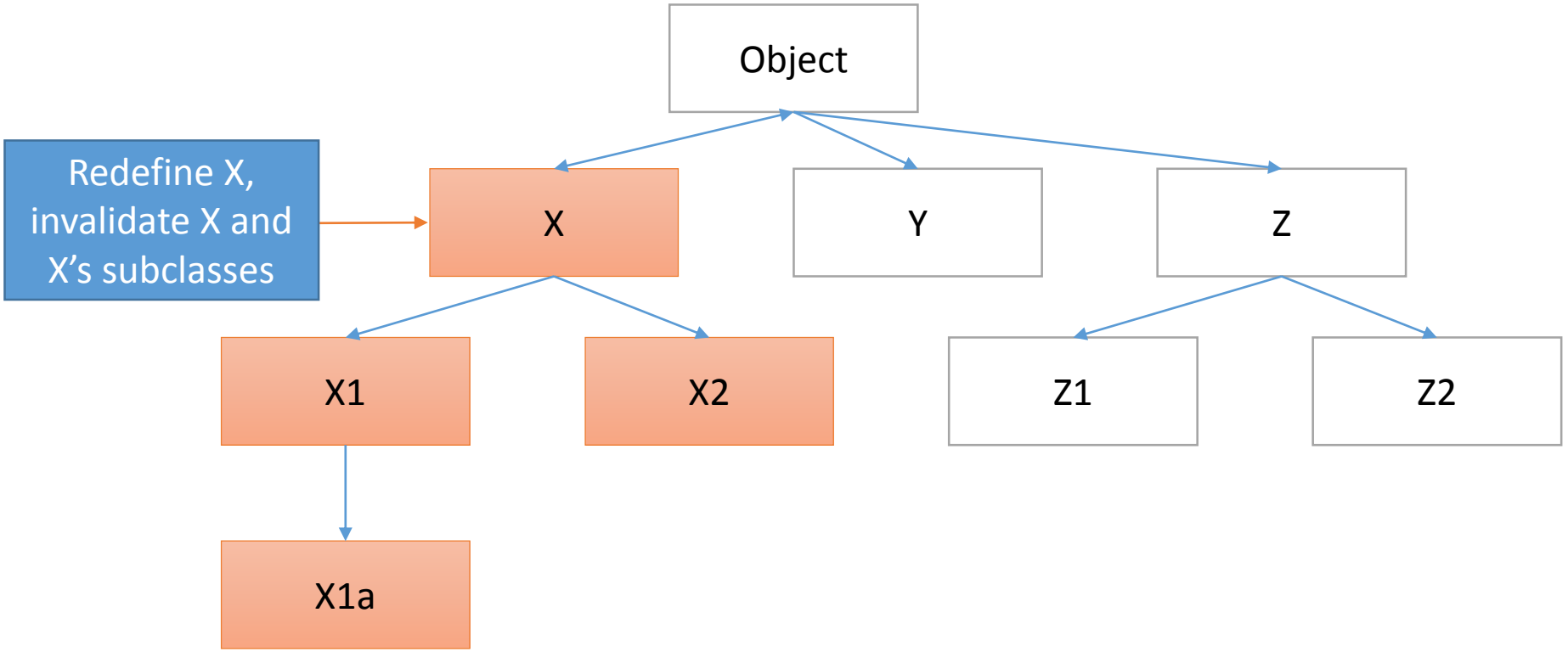
“This patch adds class hierarchy method caching to CRuby. This is the algorithm used by JRuby and Rubinius.”

[ruby-core:55053] [ruby-trunk - Feature #8426][Open]
Implement class hierarchy method caching

by Charlie Somerville

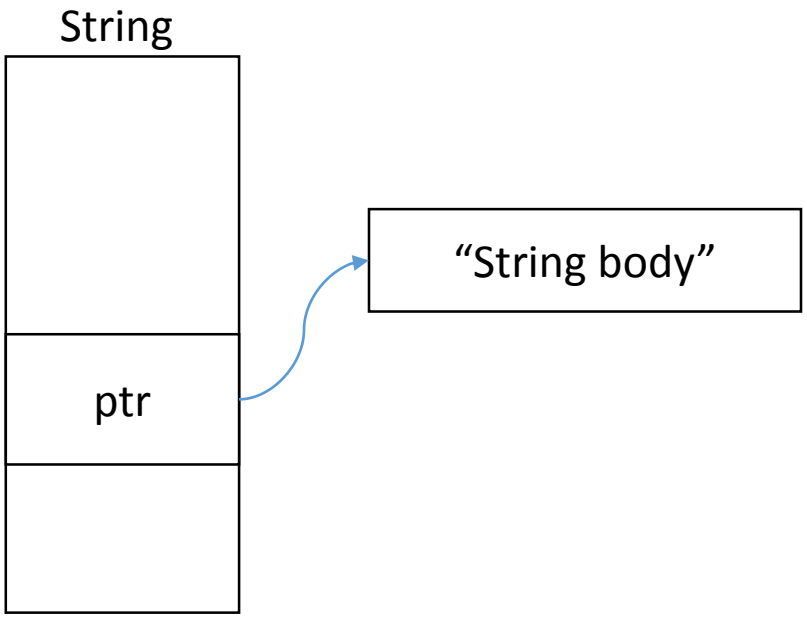
Sophisticated inline cache invalidation mechanism

- Invalid only sub-classes under effective class



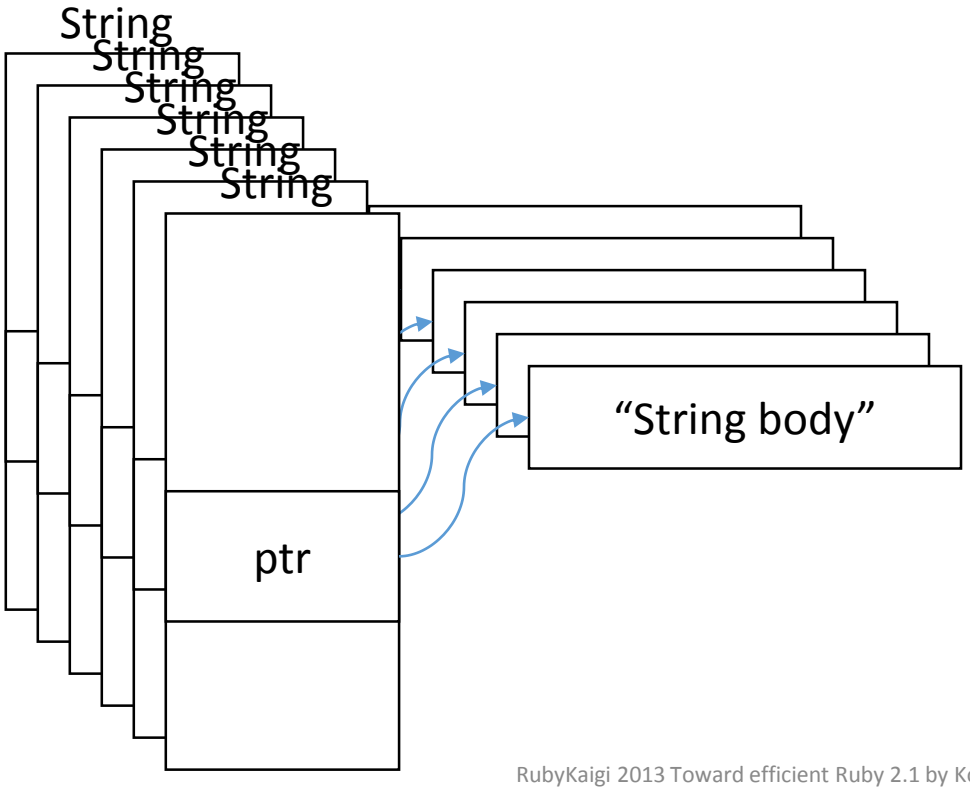
Memory efficient string management

- Each string has their string body (space acquired by malloc())



Memory efficient string management

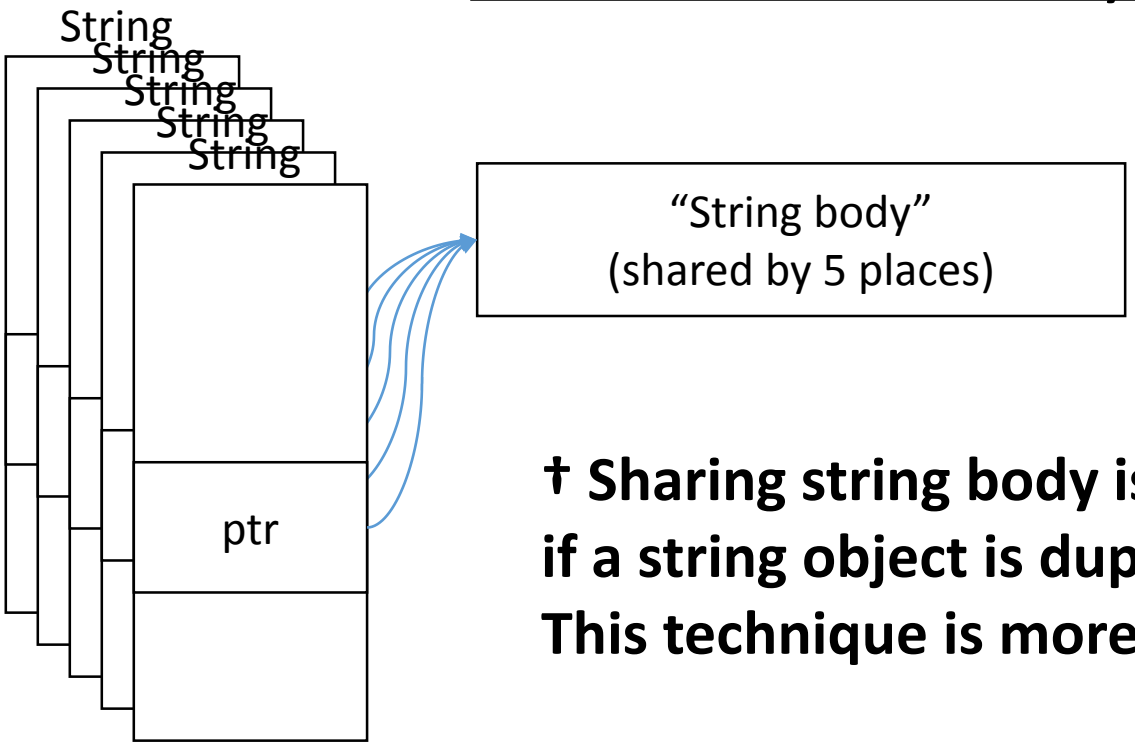
- For some strings have same “string body”, they has own string body each other.



Memory efficient string management

- It can be shared by strings w/ dirty bit.

→ Reduce memory consumption!!

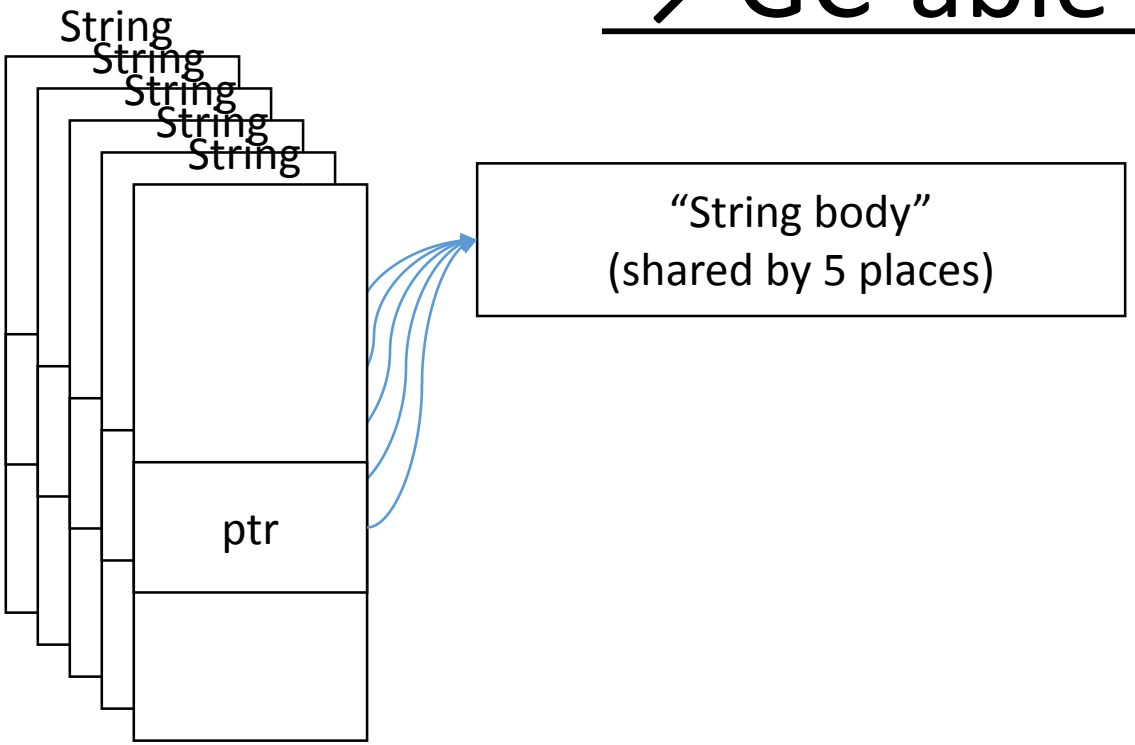


† Sharing string body is implemented now if a string object is duped.
This technique is more aggressive approach.

Memory efficient string management

- This mechanism can work with Symbol management

→ GC-able Symbol



Quoted “2.1”

“2:1 And the heavens and the earth were finished, and all the host of them.”

- Genesis

“2:1 こうして天と地と、その万象とが完成した。”

- 創世記

Agenda

- Ruby 2.1 Schedule
- Ruby 2.1 new “internal” features
  - Internal object management hooks
    - Object allocation tracing
    - GC hooks
  - **RGenGC: Restricted Generational Garbage Collection ← Today’s main topic**
- Ruby 2.1 expected “internal” features
  - Sophisticated inline cache invalidation mechanism
  - Memory efficient string management
  - Useful debugger

Summary

- We are implementing new features and improving Ruby's quality for Ruby 2.1
- Especially introducing "Generational garbage collector" which I'm working on will improve huge performance
- Ruby 2.1 is currently scheduled on Dec 25, 2013

Thank you

Any questions?

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