Memory management tuning in Ruby

Koichi Sasada

<ko1@heroku.com>

Summary of this talk

- Introduction of new versions
  - Ruby 2.1 (2.1.1 was released)
  - Ruby 2.2 (currently working on)
- Basic of Ruby’s memory management (GC)
- GC tuning parameters
  - **“What”** and **“How”** we can tune by GC parameters

Who am I ?

- Koichi Sasada a.k.a. ko1
- From Japan
- 笹田 (family name) 耕一 (given name) in Kanji character
  - "Ichi" (Kanji character "一") means "1" or first
  - This naming rule represents I'm the first son of my parents
  - Ko"ichi" → ko1

Who am I ?

- CRuby/MRI committer
  - Virtual machine (YARV) from Ruby 1.9
  - YARV development since 2004/1/1
  - Recently, improving GC performance
- Matz team at Heroku, Inc.
  - Full-time CRuby developer
  - Working in Japan
- Director of Ruby Association

Advertisement

Ruby Association

- Foundation to encourage Ruby developments and communities
  - Chairman is Matz
  - Located at Matsue-city, Shimane, Japan
- Activities
  - Maintenance of Ruby (Cruby) interpreter
    - Now, it is for Ruby 1.9.3
    - Ruby 2.0.0 in the future?
  - Events, especially RubyWorld Conference
  - Ruby Prize
  - Grant project. We have selected **3 proposals** in 2013
    - Win32Utils Support, Conductor, Smalruby - smalruby-editor
    - We will make this grant 2014!!
  - **Donation** for Ruby developments and communities

Advertisement

- Heroku, Inc. http://www.heroku.com

You should know about Heroku!!

- Heroku supports Ruby development
  - Many talents for Ruby, and also other languages
  - Heroku employs 3 **Ruby interpreter core developers**
    - Matz
    - Nobu
    - Ko1 (me)
  - We name our group “Matz team”

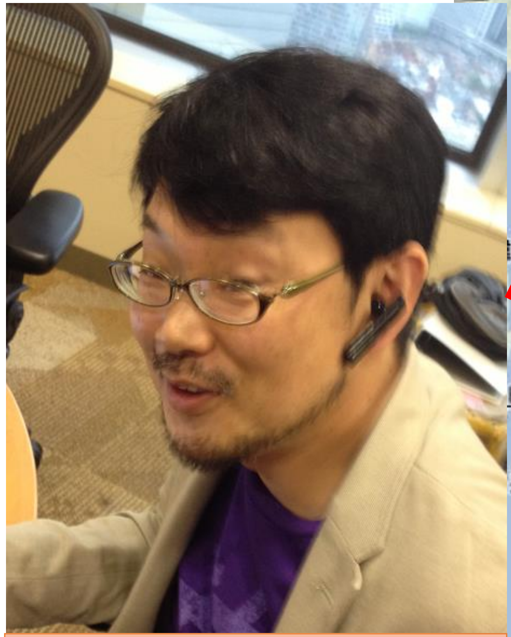
This talk is also sponsored by Heroku!

“Matz team” in Heroku

Matz team in Heroku in Japan

Nobu @ Tochigi
Patch monster

札幌
青森
秋田
盛岡
日本海
日本
仙台
新潟
福島
富山
長野
金沢
甲府
東京
松江
鳥取
名古屋
大阪
静岡
津
山口
広島
岡山
福岡
大分
松山
高知
長崎
熊本
宮崎
鹿児島



Matz @ Shimane
Title collector

ko1 @ Tokyo
EDD developer

Matz team at Heroku Hierarchy

Matz @ Shimane
Title collector

[Not stupid boss]

Communication
with Skype

ko1 @ Tokyo
EDD developer

Nobu @ Tochigi
Patch monster

Matz
Title collector

- He has so many (job) title
  - Chairman - Ruby Association
  - Fellow - NaCl
  - Chief architect, Ruby - Heroku
  - Research institute fellow – Rakuten
  - Chairman – NPO mruby Forum
  - Senior researcher – Kadokawa Ascii Research Lab
  - Visiting professor – Shimane University
  - Honorable citizen (living) – Matsue city
  - Honorable member – Nihon Ruby no Kai
  - …
- This margin is too narrow to contain

Message from Matz

“I am awfully sorry for not being here.

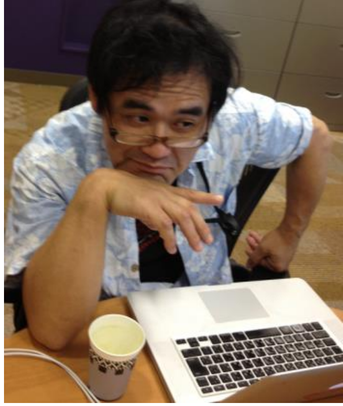
But I love you.

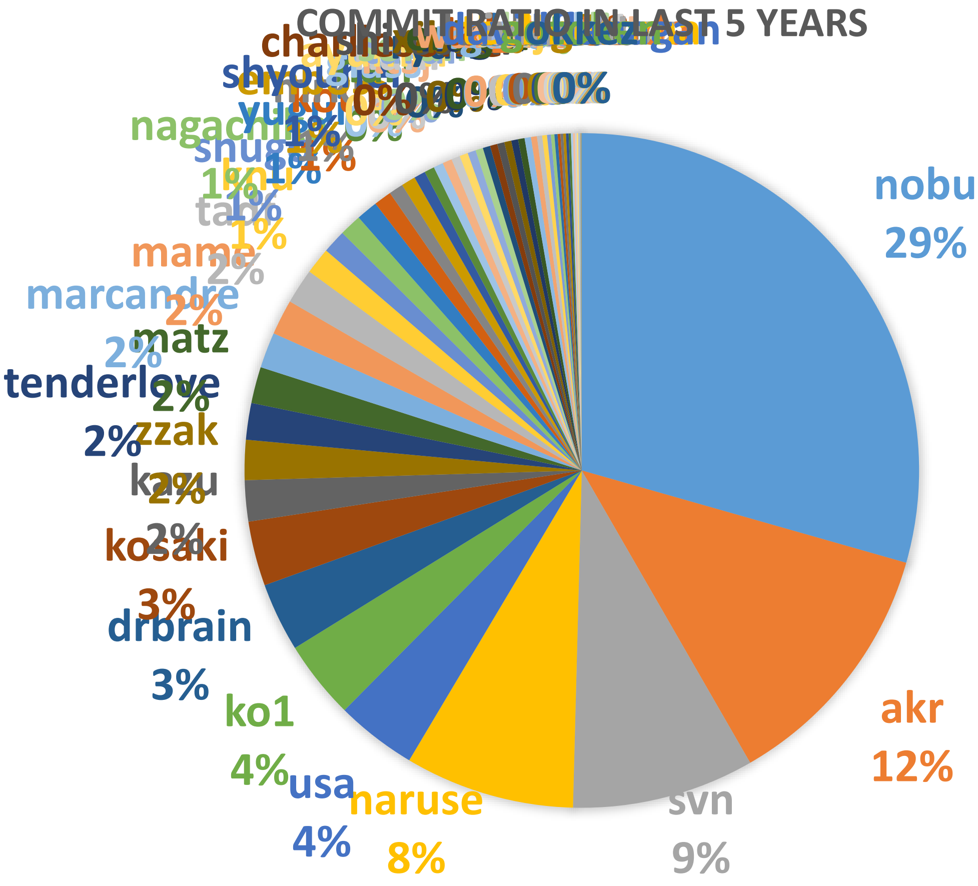
Maybe next time!”

Nobu
Patch monster

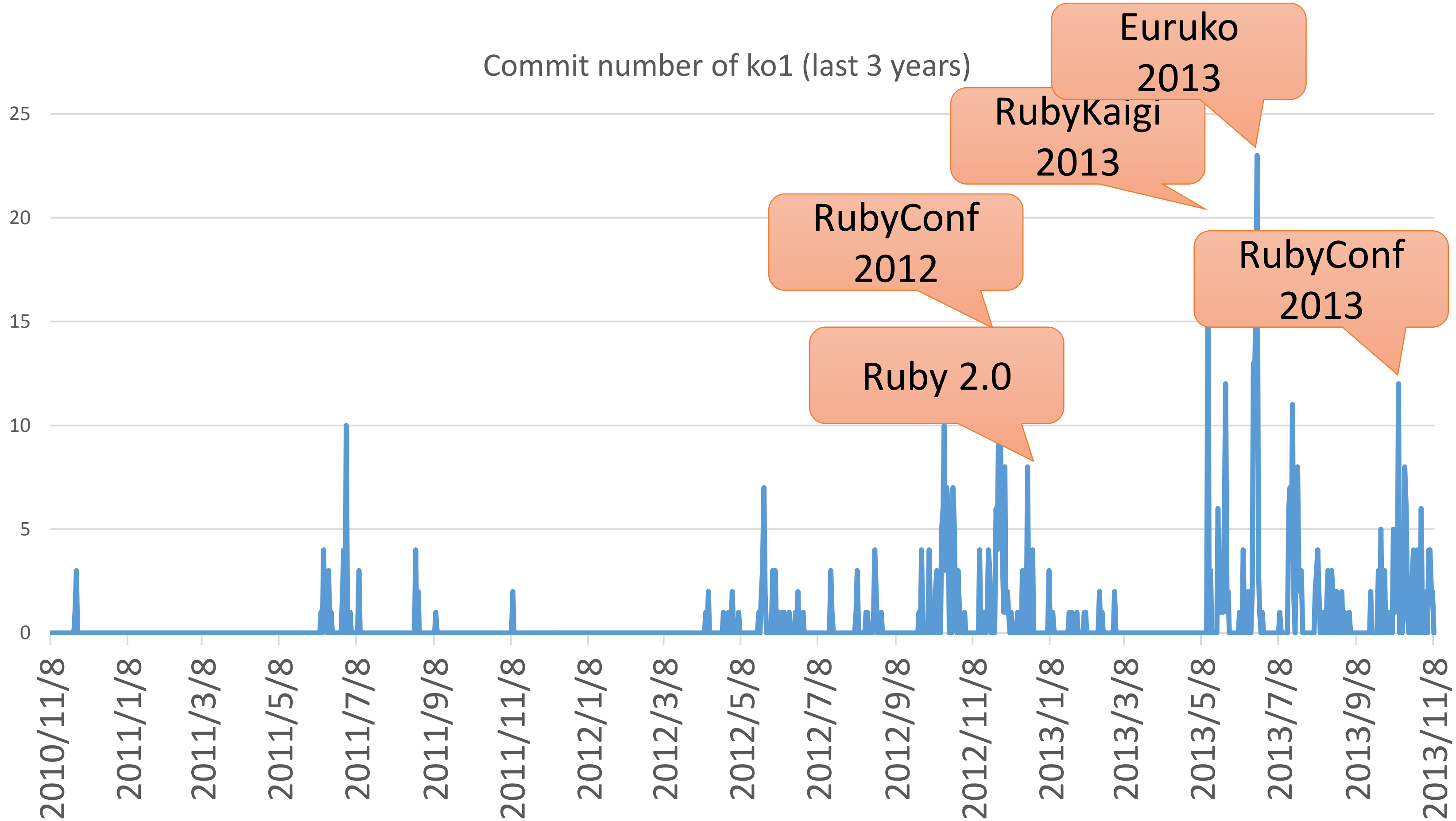
- Great patch creator

Nobu
Patch monster





Ko1
EDD developer



EDD: Event Driven Development

Mission of Matz team

- **Improve quality of next version of CRuby**
  - Matz decides a spec finally
  - Nobu fixed huge number of bugs
  - Ko1 improves the performance

Current target is Ruby 2.2!!

Now, Ruby 2.1 is old version for us.

Ruby 2.1
Current stable

http://www.flickr.com/photos/loginesta/5266114104

Ruby 2.1

- **Ruby 2.1.0** was released at **2013/12/25**
  - New features
  - Performance improvements
- **Ruby 2.1.1** was released at **2014/02/24**
  - Includes many bug fixes found after 2.1.0 release
  - Introduce a new GC tuning parameter to change generational GC behavior (introduce it later)

Ruby 2.1 the biggest change Version policy

- Change the versioning policy
  - Drop “patch level” in the version
  - Teeny represents patch level
    - Release new teeny versions about every 3 month
    - Teeny upgrades keep compatibility
  - Minor upgrades can break backward compatibility
    - We make an effort to keep compatibility

      (recently. Remember Ruby 1.9 ☺)

Ruby 2.1 New syntax

- New syntaxes
  - Required keyword parameter
  - Rational number literal
  - Complex number literal
  - `def’ returns symbol of method name

```
    **** COMMODORE 64 BASIC V2 ****
 64K RAM SYSTEM  38911 BASIC BYTES FREE
READY.
SHIFTRUNSTOP.CO.UK
?SYNTAX  ERROR
READY.
```

http://www.flickr.com/photos/rooreynolds/4133549889

Ruby 2.1 Syntax
Required keyword parameter

- Keyword argument (from Ruby 2.0.0)
  - def foo(a: 1, b: 2); end
  - `a’ and `b’ are optional parameters
  - OK: foo(); foo(a: 1); foo(a: 1, b: 2); foo(b: 2)
- Required keyword argument from 2.1
  - def foo(a: 1, b:)
  - `a’ is optional, but `b’ is required parameter
  - OK: foo(a: 1, b: 2); foo(b: 2)
  - NG: foo(); foo(a: 1)

Ruby 2.1 Syntax
Rational number literals

- To represent ½, in Ruby “Rational(1, 2)”

  → Too long!!

- Introduce “r” suffix

  ½ → 1/2r

- “[digits]r” represents “Rational([digits], 1)”
- ½ → 1/2r
  - 1/2r #=> 1/Rational(2, 1)
  - 1/Rational(2, 1) #=> Rational(1/2)

Ruby 2.1 Syntax
Complex number literals

- We already have “Integer#i” method to make imaginary number like “1+2.i”
- We already introduced “r” suffix for Rational

  → No reason to prohibit “i” suffix!!
- [digits]i represents “Complex(0, [digits])”
- 1+2i #=> 1+Complex(0, 2)
- 1+Complex(0, 2) #=> Complex(1, 2)

- You can mix “r” and “i” suffix

Ruby 2.1 Syntax Return value of `def’ syntax

- Return value of method definition
  - Method definition syntax returns symbol of defined method name
  - `def foo; …; end’ #=> :foo
- Method modifier methods
  - Example:
    - private def foo; …; end
    - public static void def main(args); …; end

Ruby 2.1 Runtime new features

- String#scrub
- Process.clock_gettime
- Binding#local_variable_get/set
- Bignum now uses GMP (if available)
- Extending ObjectSpace

Ruby 2.1 Runtime new features Object tracing

- 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
}
```

Performance improvements

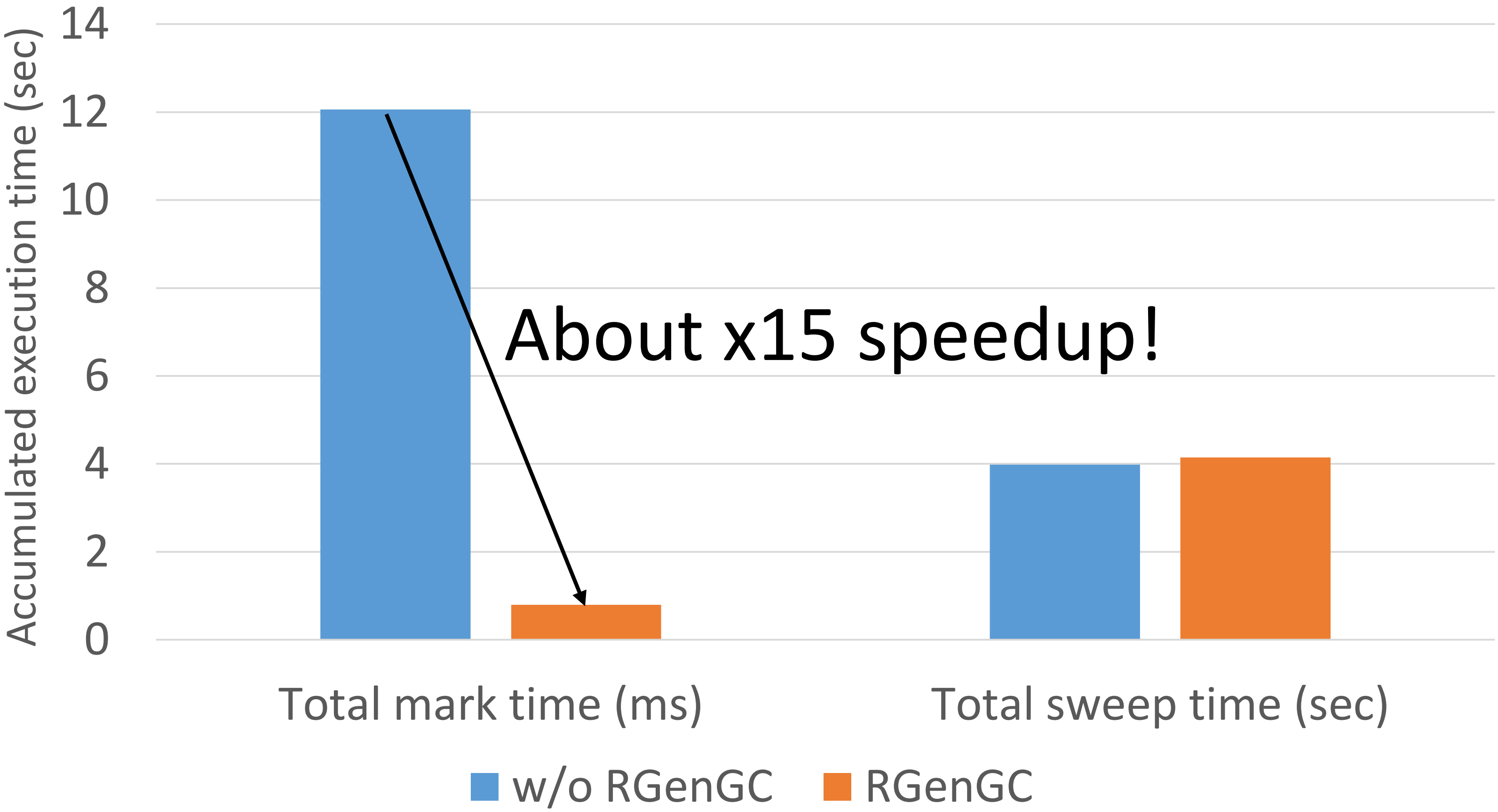
- Optimize “string literal”.freeze
- Sophisticated inline method cache
- Introducing Generational GC: RGenGC

RGenGC: Generational GC for Ruby

- RGenGC: Restricted Generational GC
  - Generational GC (minor/major GC uses M&S)
  - **Dramatically speedup for GC-bottleneck applications**
  - New generational GC algorithm allows mixing “Write-barrier protected objects” and “WB unprotected objects”

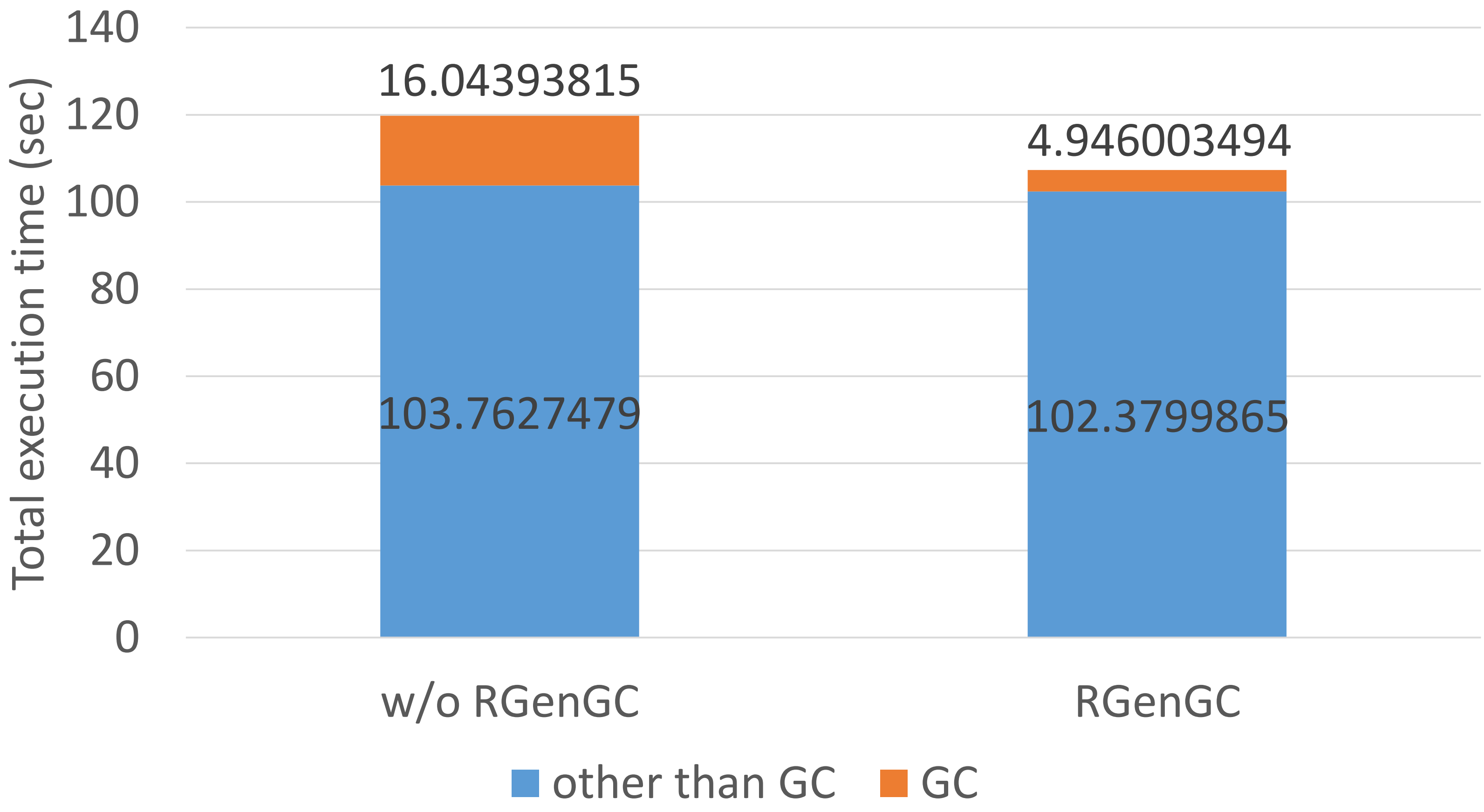
  → **No** (mostly) **compatibility issue** with C-exts
- Inserting WBs gradually
  - We can concentrate WB insertion efforts for major objects and major methods
  - Now, most of objects (such as Array, Hash, String, etc.) are WB protected
    - Array, Hash, Object, String objects are very popular in Ruby
    - Array objects using **RARRAY_PTR() change to WB unprotected** objects (called as Shady objects), so existing codes still works.

RGenGC
Performance evaluation (RDoc)



* Disabled lazy sweep to measure correctly.

RGenGC
Performance evaluation (RDoc)



* 12% improvements compare with w/ and w/o RGenGC

* Disabled lazy sweep to measure correctly.

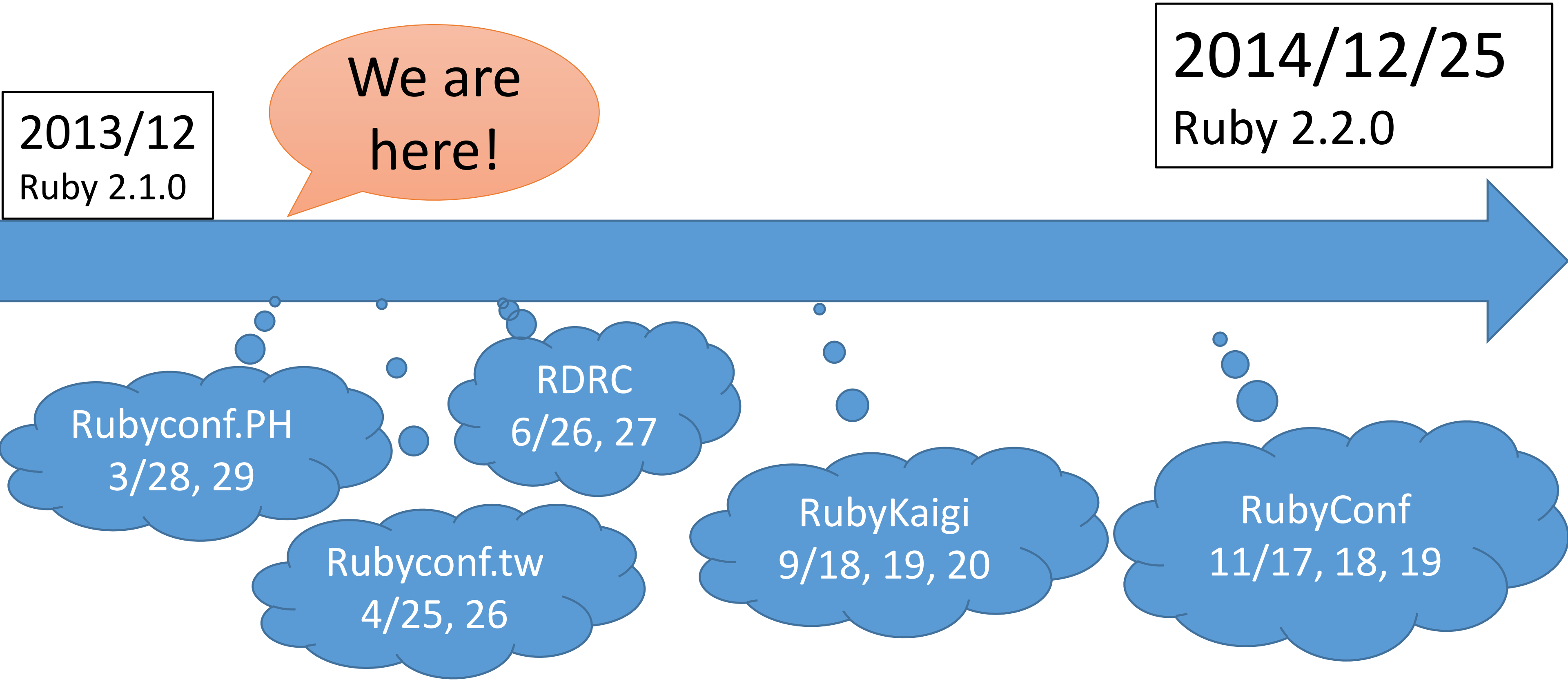
Ruby 2.2
Next version

http://www.flickr.com/photos/adafruit/8483990604

Schedule of Ruby 2.2

- Not published officially
- Schedule draft is available by Naruse-san
  - https://bugs.ruby-lang.org/projects/ruby-trunk/wiki/ReleaseEngineering22

Ruby 2.2 schedule



2013/12
Ruby 2.1.0

We are here!

2014/12/25
Ruby 2.2.0

Rubyconf.PH
3/28, 29

Rubyconf.tw
4/25, 26

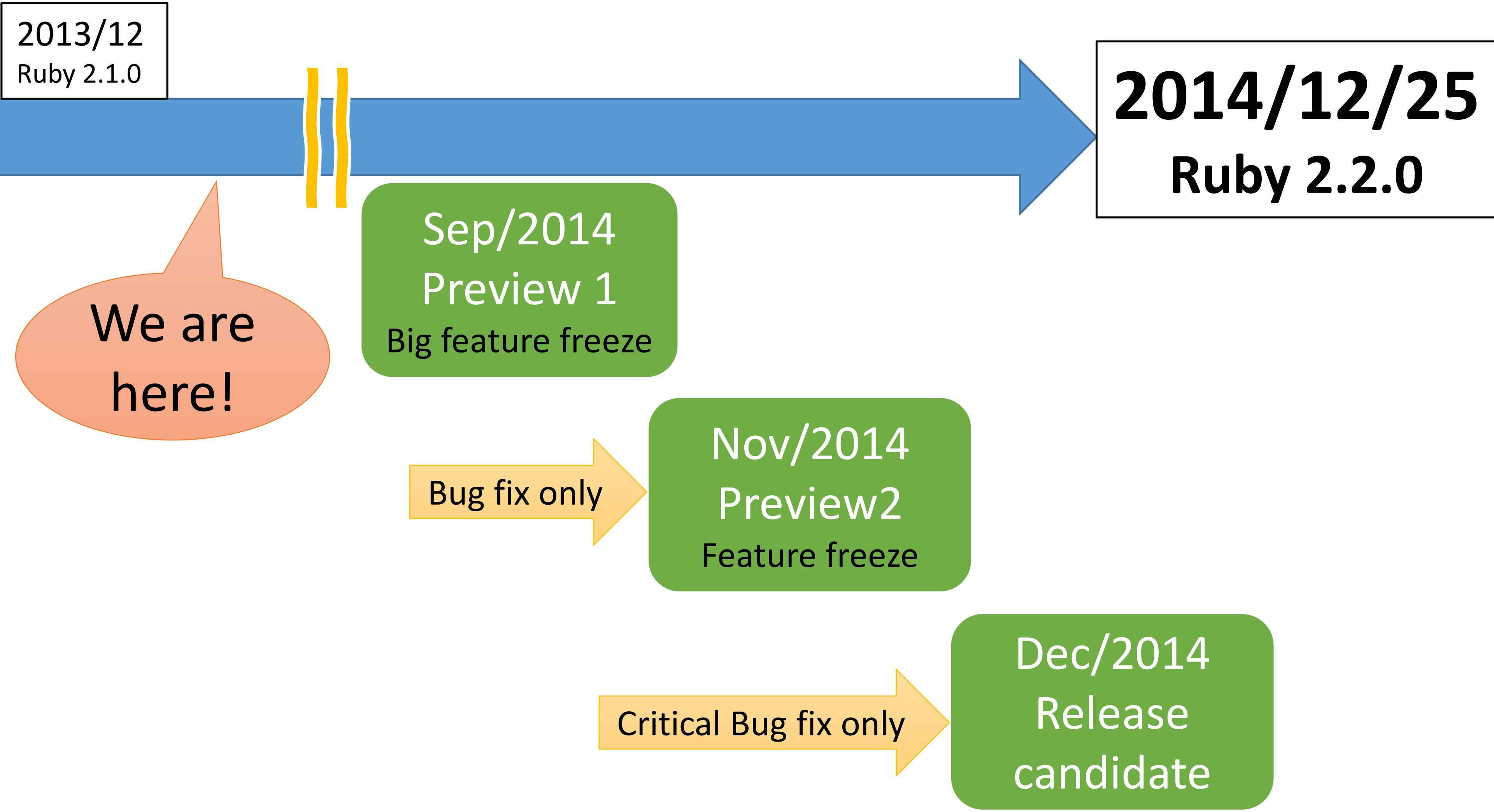
RDRC
6/26, 27

RubyKaigi
9/18, 19, 20

RubyConf
11/17, 18, 19

Events are important for
EDD (Event Driven Development) Developers

Ruby 2.2 (rough) schedule



2013/12
Ruby 2.1.0

2014/12/25
Ruby 2.2.0

We are here!

Sep/2014
Preview 1
Big feature freeze

Bug fix only

Nov/2014
Preview2
Feature freeze

Critical Bug fix only

Dec/2014
Release candidate

2.2 big features (planned)

- New syntax: not available now
- New method: not available now
- Internal
  - GC
    - **Symbol GC (merged recently)**
    - **2age promotion strategy for RGenGC**
    - **Incremental GC** to reduce major GC pause time
  - VM
    - More sophisticated method cache

Symbol GC

- Symbols remain forever → Security issue
  - “n.times{|i| i.to_s.to_sym}”

    creates “n” symbols and they are never collected
- Symbol GC: Collect dynamically created symbols

Garbage collection
The automatic memory management

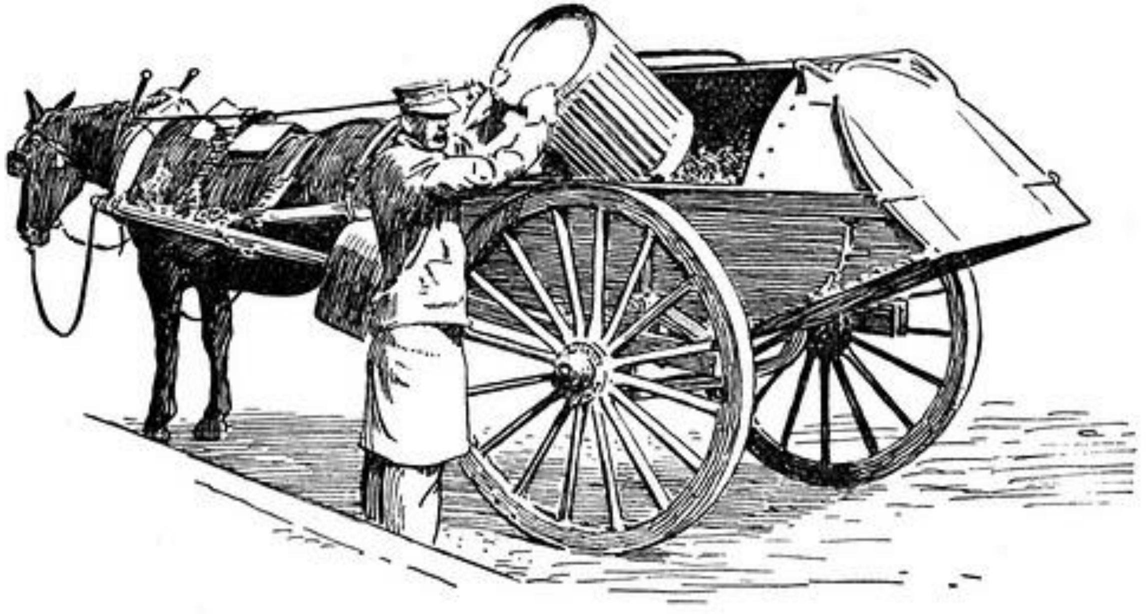


FIG. 109. — A GARBAGE COLLECTOR.

http://www.flickr.com/photos/circasassy/6817999189/

Today’s main subject

From basic to advanced topics

Automatic memory management Basic concept

- “Object.new” allocate a new object
  - “foo” (string literal) also allocate a new object
  - Everything are objects in Ruby!
- We don’t need to **“de-allocate”** objects manually

Automatic memory management Basic concept

- **Garbage collector recycled “unused” objects automatically**

1st question

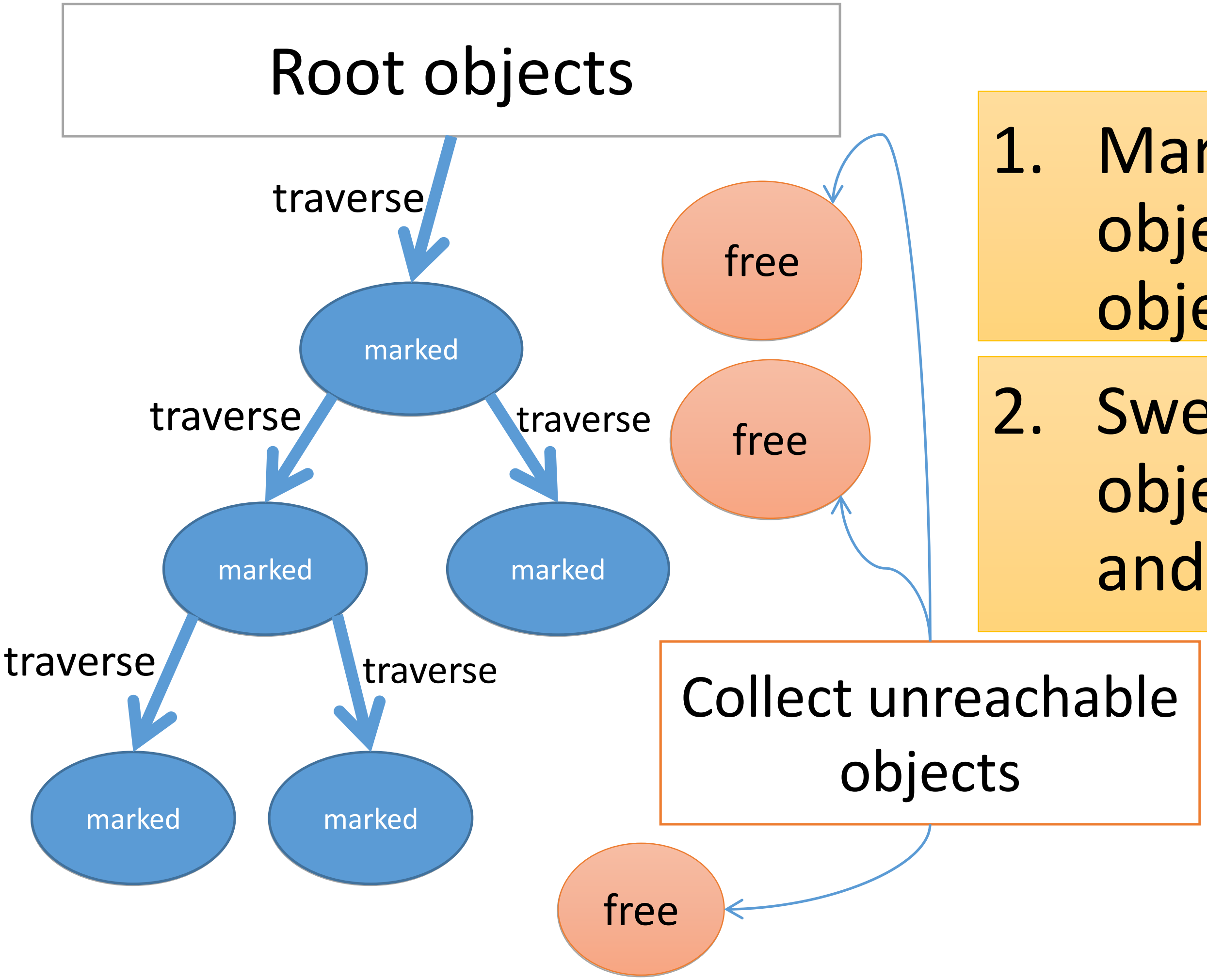
How to collect “unused” objects?

How to collect “unused” objects?

- Using (well-known) GC algorithm
  - Mark and sweep algorithm (from the first version of Ruby)
  - Generational GC algorithm (from Ruby 2.1)

http://www.flickr.com/photos/mirsasha/5644819639/

Mark & Sweep algorithm



Root objects

traverse

marked

traverse

traverse

marked

marked

traverse

traverse

marked

marked

free

free

free

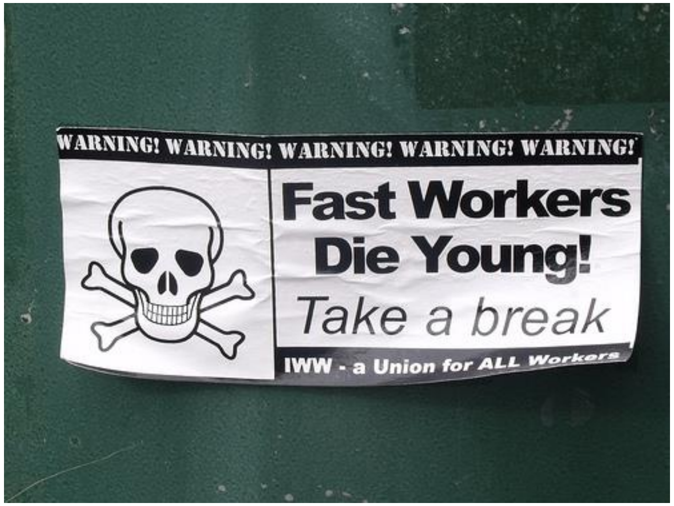
Collect unreachable objects

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

Generational GC (GenGC)

- Weak generational hypothesis:

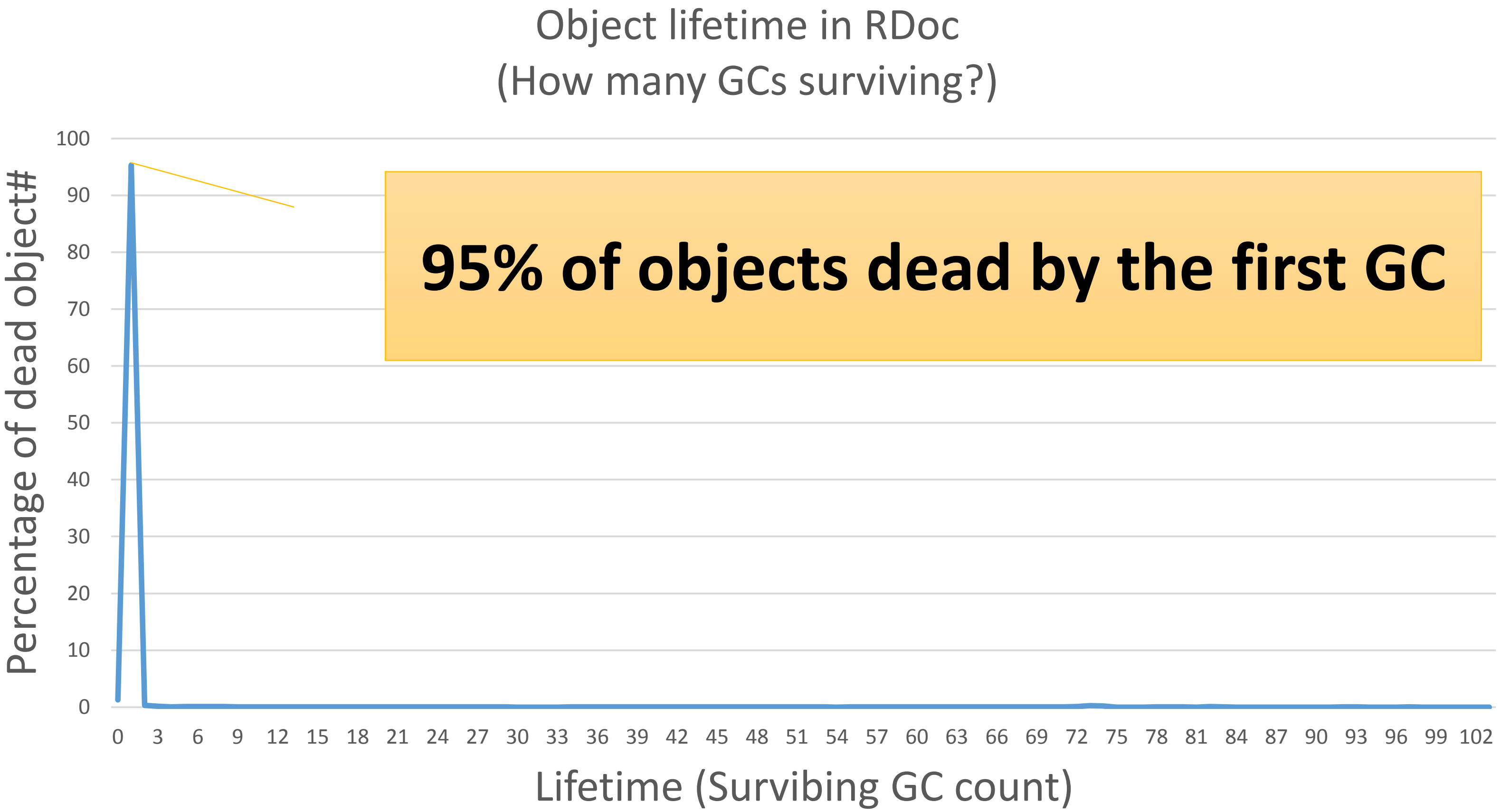
“Most objects die young”


WARNING! WARNING! WARNING! WARNING! WARNING!
Fast Workers
Die Young!
Take a break
IWW - a Union for ALL Workers

http://www.flickr.com/photos/ell-r-brown/5026593710

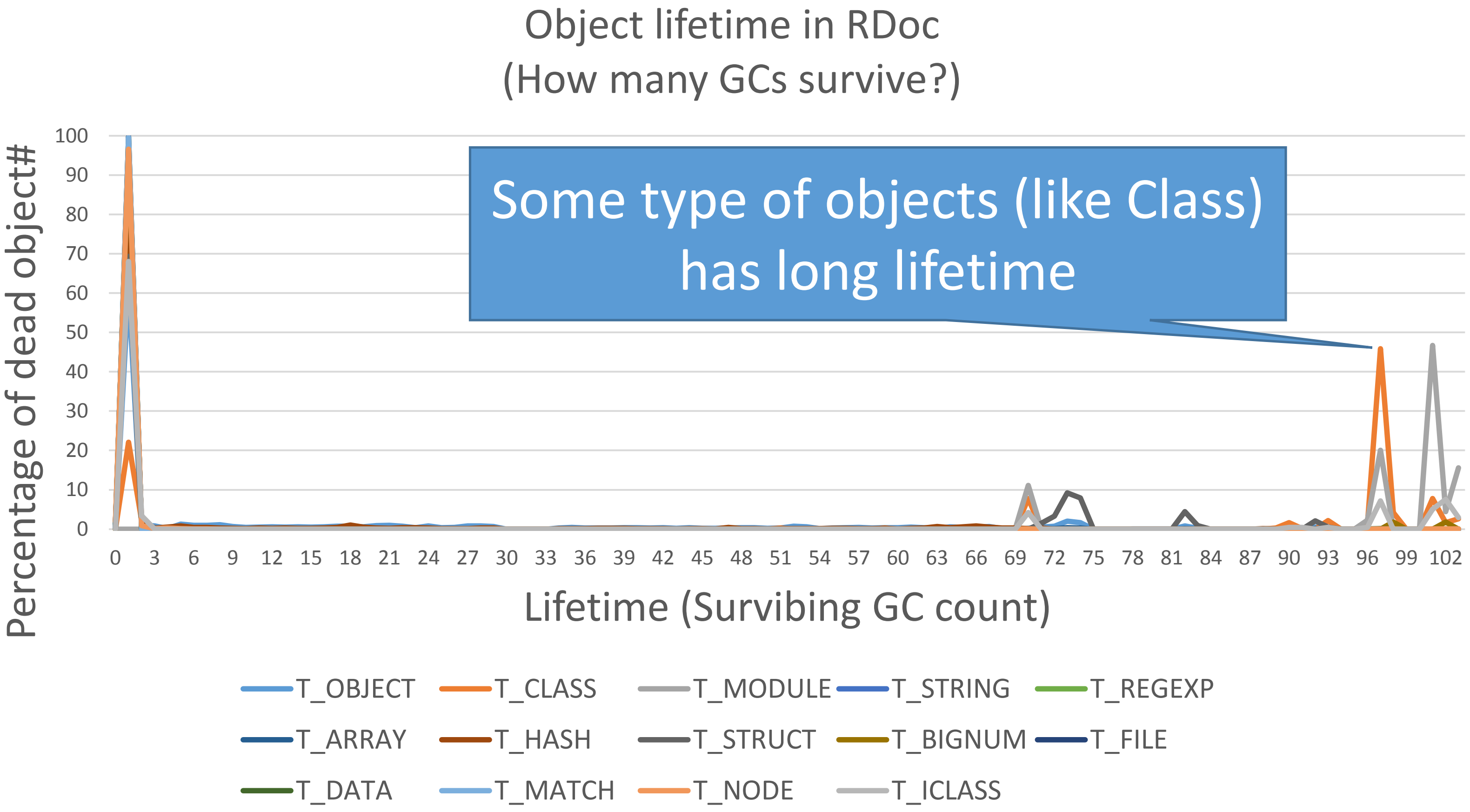
→ Concentrate reclamation effort only on the young objects

Generational hypothesis



95% of objects dead by the first GC

Generational hypothesis



Some type of objects (like Class) has long lifetime

Generational GC (GenGC)

- Separate young generation and old generation
  - Create objects as young generation
  - Promote to old generation after surviving *n-th* 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)

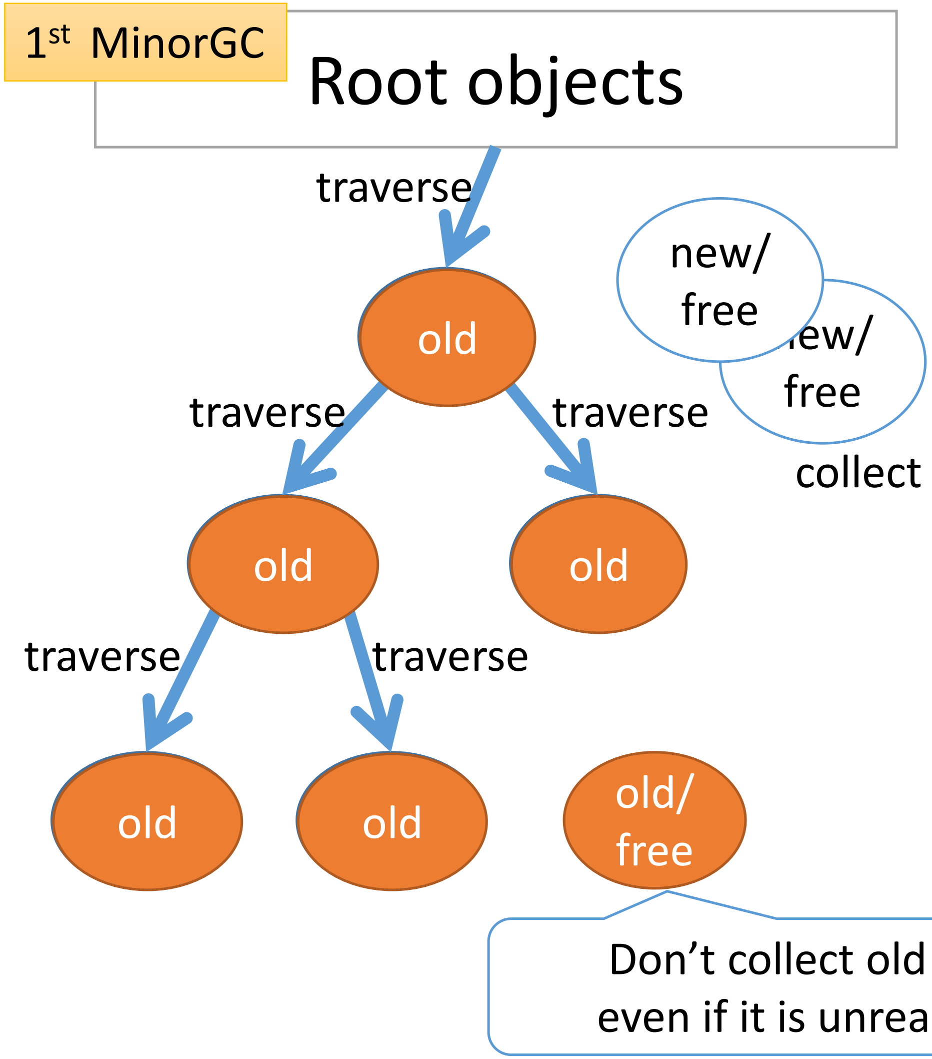
Generational GC (GenGC)

- Minor GC and Major GC can use different GC algorithm
  - Popular combination is:

    Minor GC: Copy GC, Major GC: M&S
  - **On the CRuby, we choose:**

    Minor GC: M&S, Major GC: M&S
  - Because of CRuby’s restriction (we can’t use moving algorithm)

GenGC [Minor M&S GC] (1/2)



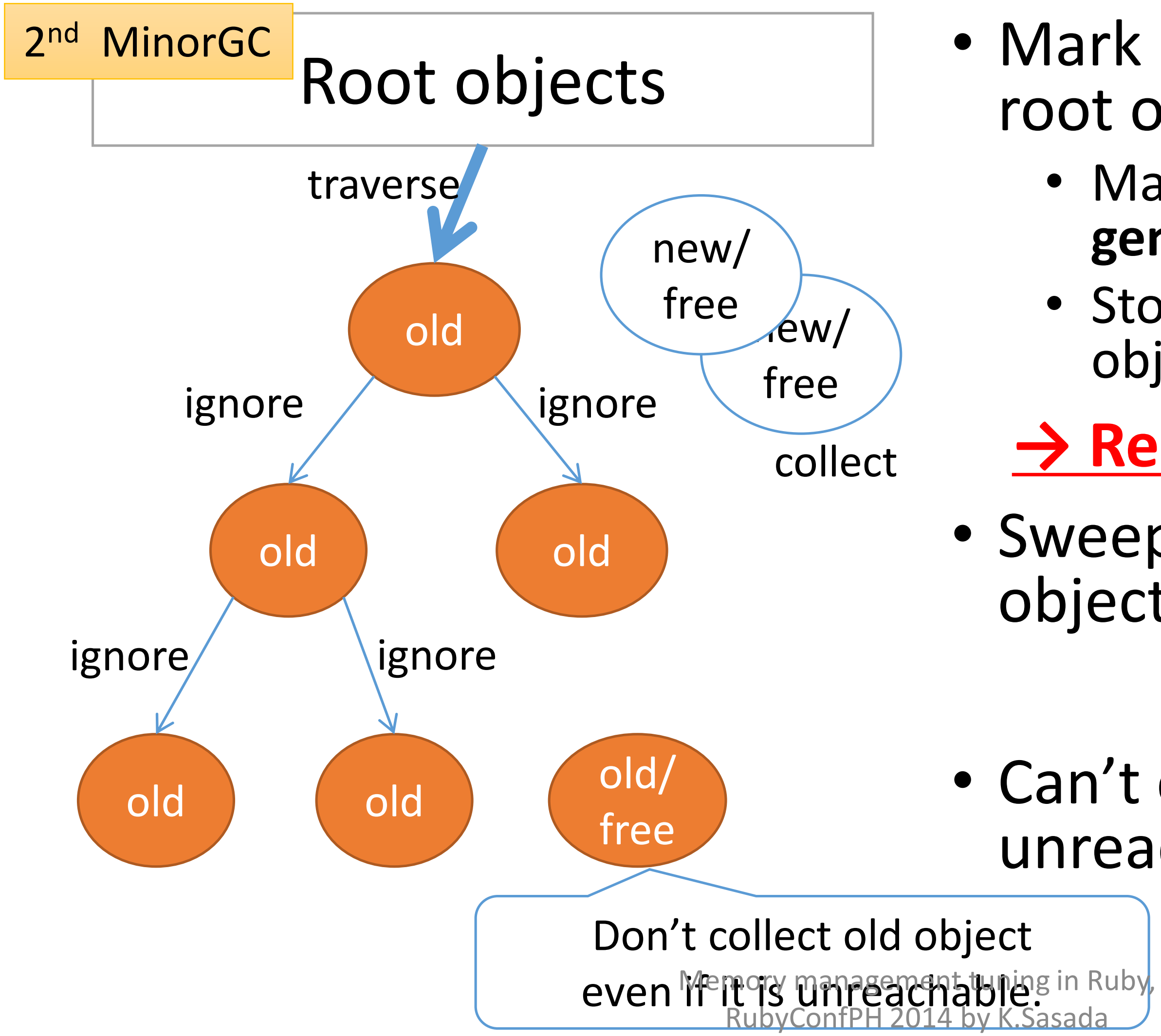
Don’t collect old object even if it is unreachable.

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

→ Reduce mark overhead

- Sweep not (marked or old) objects
- Can’t collect Some unreachable objects

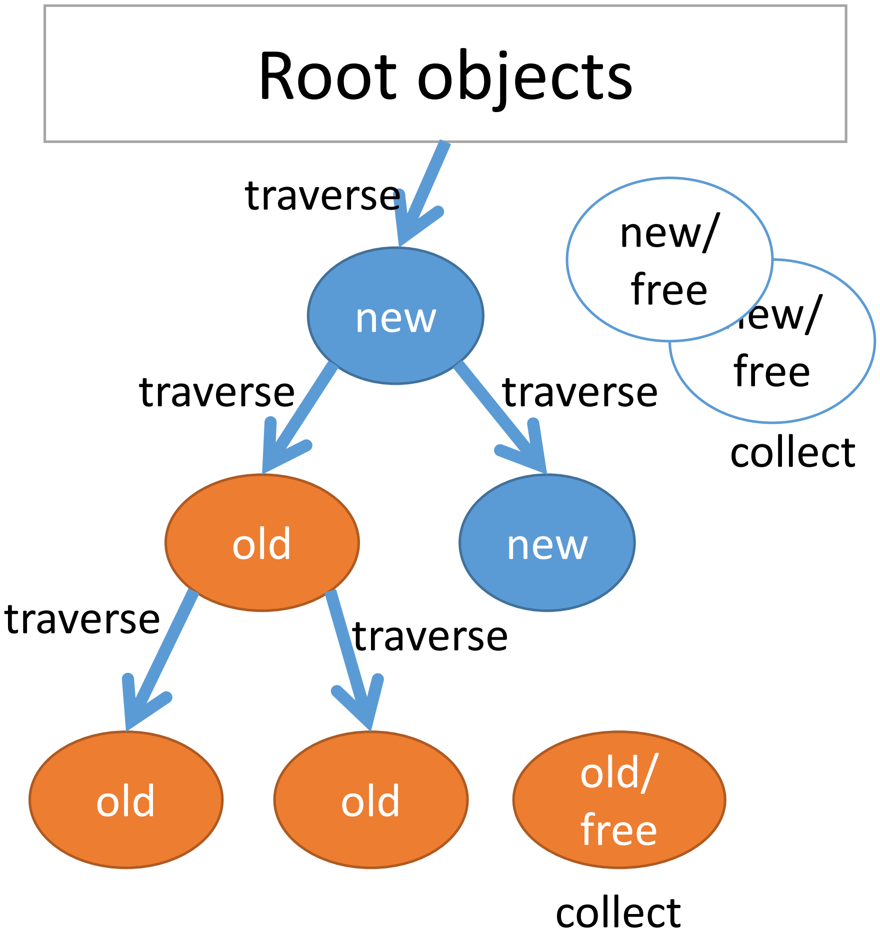
GenGC [Minor M&S GC] (2/2)



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

  → Reduce mark overhead
- Sweep not (marked or old) objects
- Can't collect Some unreachable objects

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*

NOTE: Generational GC details

- Skip details of generational GC
  - Remember set
  - Write barrier
  - RGenGC techniques

- See my previous slides for details
  - http://www.atdot.net/~ko1/activities/#idx4

2nd question

“When” should we collect objects?

“When” collect objects?

1. Object space is full
2. Exceed limit of Malloc’ed memory size
3. User specified timing (GC.start, etc)

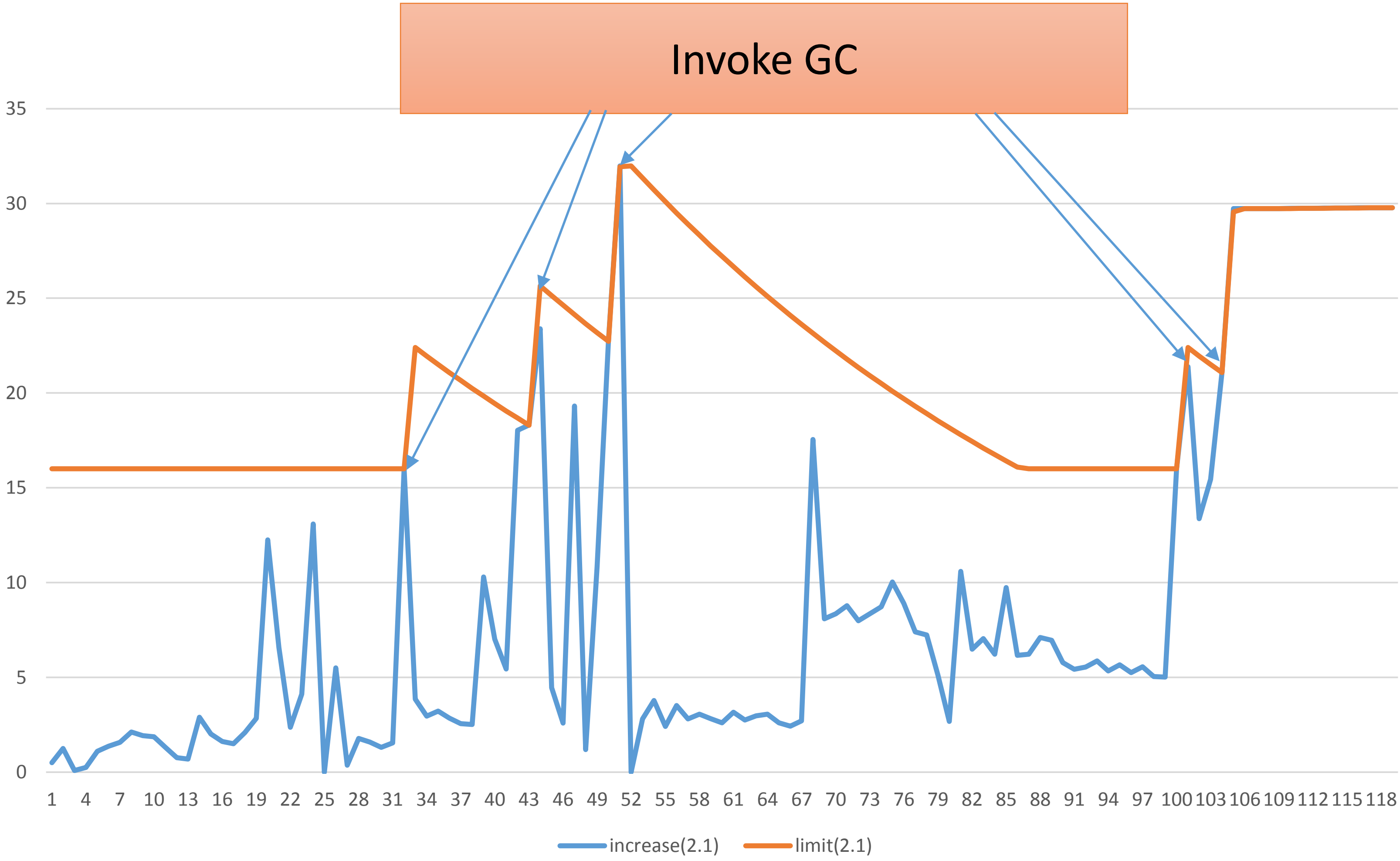
- (1) and (3) is easy to understand
- (2) needs more explanation

Exceed limit of Malloc’ed memory size

- When many memories are allocated by “malloc()”
- Introduce two variables
  - a counter “malloc_increase”
  - a threshold value “malloc_limit” (16MB)
- Rule
  - (1) Increase “malloc_increase” by malloc’ed size
  - (2) “malloc_increase” is reset at every GC time

  → “malloc_increase” represents “how many memory allocated (by malloc()) without GC”
- If “malloc_increase” > “malloc_limit”, then invoke GC to recycle malloc’ed objects

Exceed limit of Malloc’ed memory size


Invoke GC

3rd question

“What happen” when no space after GC?

What happen when no space after GC?

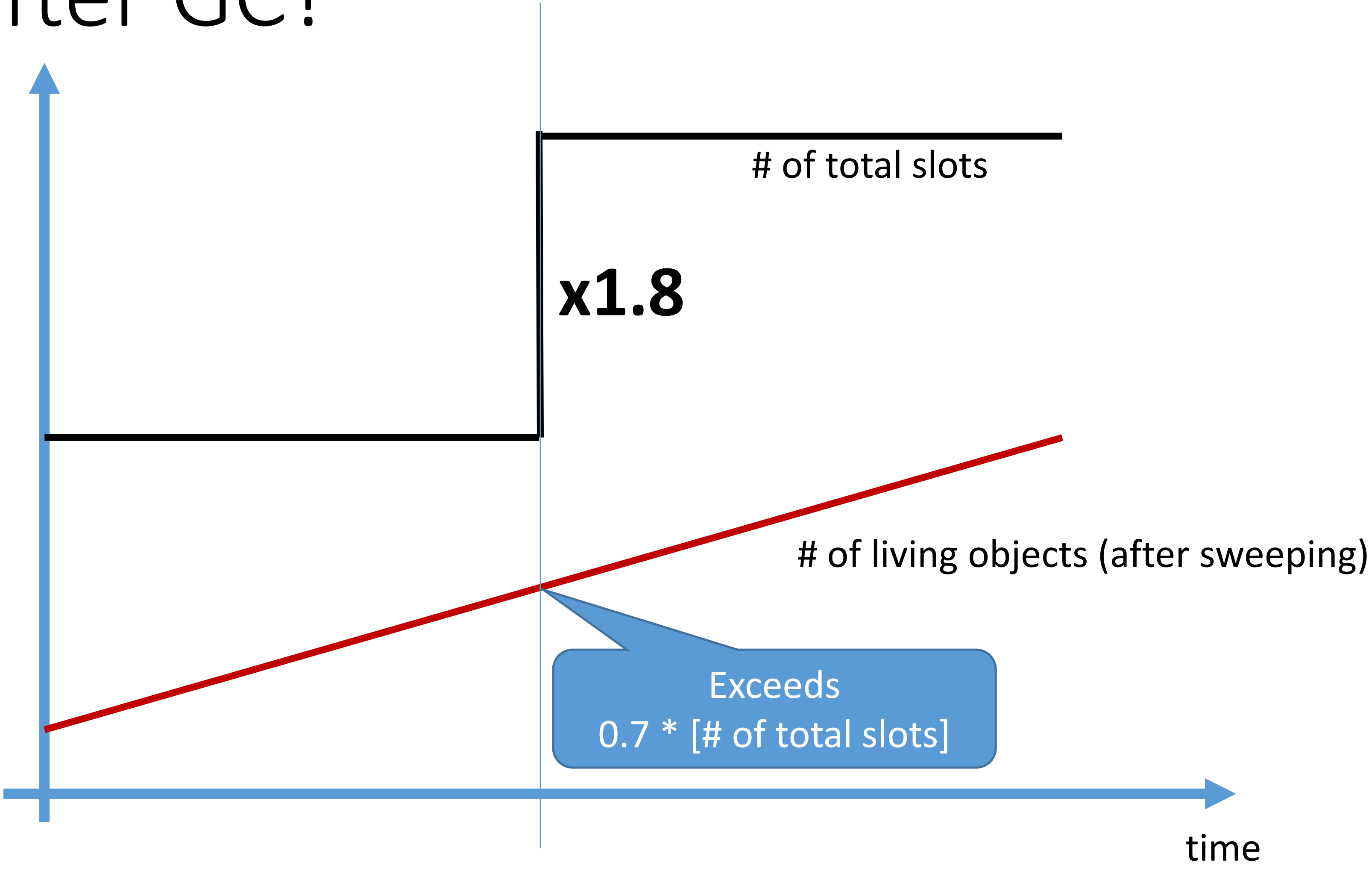
- Terminology
  - Total slots: total prepared object places
  - Living objects: Used objects

- GC detects “No Space” just after sweeping

  if [# of Total slots] * 0.7 < [# of Living objects]

- Allocate new space expand current space x1.8

What happen when no space after GC?



Trade-off

Speed-Memory Trade-off

Performance v.s. **Memory usage**

- Many GCs slow application performance

- Few GC increase memory consumption

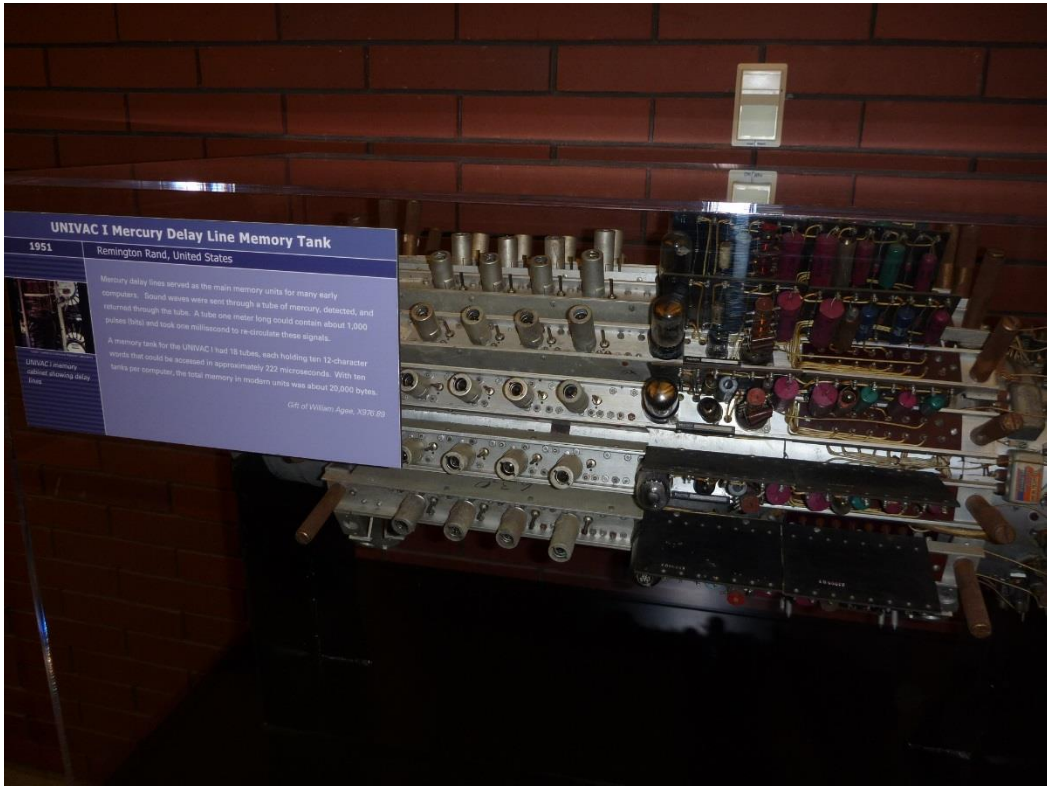
http://www.flickr.com/photos/mcerasoli/6484117955/

Speed-Memory Trade-off

- Usually no problem
- On big production application, this can be an issue

Speed-Memory Trade-off

- Solution 1: Use big memory machine



UNIVAC I Mercury Delay Line Memory Tank

1951

Remington Rand, United States

Mercury delay lines served as the main memory units for many early computers. Sound waves were sent through a tube of mercury, detected, and returned through the tube. A tube one meter long could contain about 1,000 pulses (bits) and took one millisecond to re-circulate these signals.

A memory tank for the UNIVAC I had 18 tubes, each holding ten 12-character words that could be accessed in approximately 222 microseconds. With ten tanks per computer, the total memory in modern units was about 20,000 bytes.

Gift of William Agee, X976.89

UNIVAC I memory cabinet showing delay lines

Speed-Memory Trade-off

- Solution 1: Use big memory machine
  - Recent price of memory is very cheep
  - Heroku provides “PX: Performance dyno” (6GB)

Advertisement

Heroku XL: Focusing on Large Scale Apps

Posted 2 months ago by Matt Soldo

https://blog.heroku.com/archives/2014/2/3/heroku-xl

Speed-Memory Trade-off

- Solution 2: Find out good points
  - Choose good “GC tuning parameters”

GC tuning parameters

GC tuning parameters

- There are several GC tuning parameters
  - Specified by environment variables
    - Use like that: $ RUBY_GC_INIT_SLOTS=10000 ruby script.rb
  - Affect only launched time

GC tuning parameters

- How many GC parameters now?
  - Please raise your hand if you think it is:

    ① 3

    ② 7

    ③ 10

    ④ 11

    ⑤ 13

GC tuning parameters

- How many GC parameters now?
  - Please raise your hand if you think it is:

    ① 3 (ruby 1.9)

    ② 7

    ③ 10 (ruby 2.1.0)

    ④ 11 (ruby 2.1.1) ← Now!!

    ⑤ 13

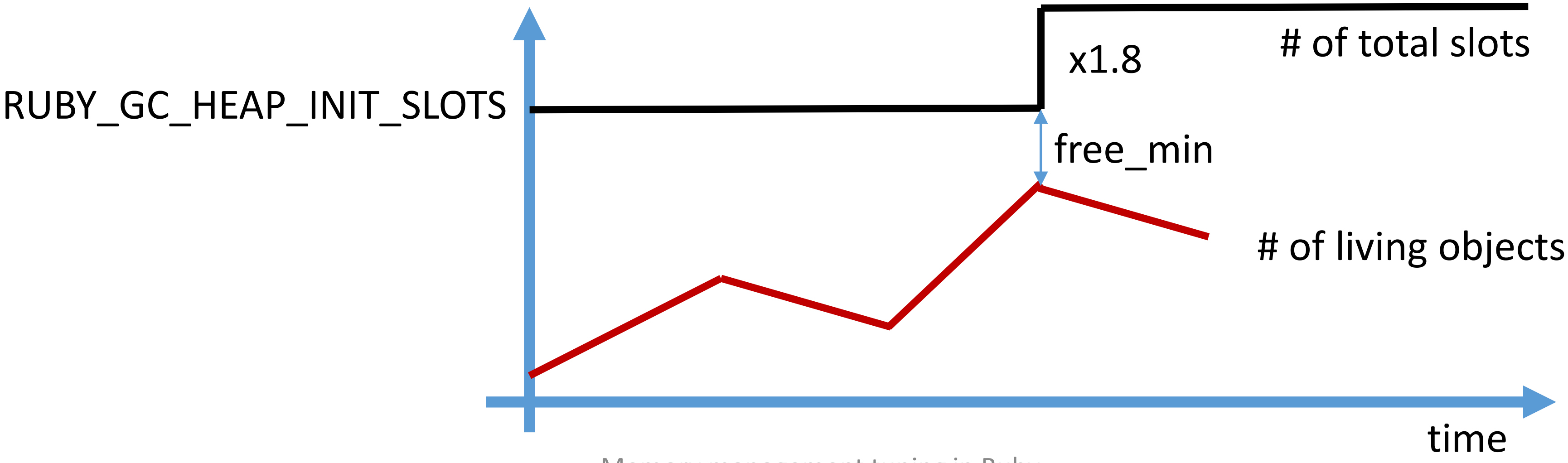
GC tuning parameters (Ruby 2.1.1)

1. RUBY_GC_HEAP_INIT_SLOTS
2. RUBY_GC_HEAP_FREE_SLOTS
3. **RUBY_GC_HEAP_GROWTH_FACTOR (new from 2.1)**
4. **RUBY_GC_HEAP_GROWTH_MAX_SLOTS (new from 2.1)**
5. **RUBY_GC_HEAP_OLDOBJECT_LIMIT_FACTOR (new from 2.1.1)**
6. RUBY_GC_MALLOC_LIMIT
7. **RUBY_GC_MALLOC_LIMIT_MAX (new from 2.1)**
8. **RUBY_GC_MALLOC_LIMIT_GROWTH_FACTOR (new from 2.1)**
9. **RUBY_GC_OLDMALLOC_LIMIT (new from 2.1)**
10. **RUBY_GC_OLDMALLOC_LIMIT_MAX (new from 2.1)**
11. **RUBY_GC_OLDMALLOC_LIMIT_GROWTH_FACTOR (new from 2.1)**

- Obsolete
  - RUBY_FREE_MIN -> RUBY_GC_HEAP_FREE_SLOTS (from 2.1)
  - RUBY_HEAP_MIN_SLOTS -> RUBY_GC_HEAP_INIT_SLOTS (from 2.1)

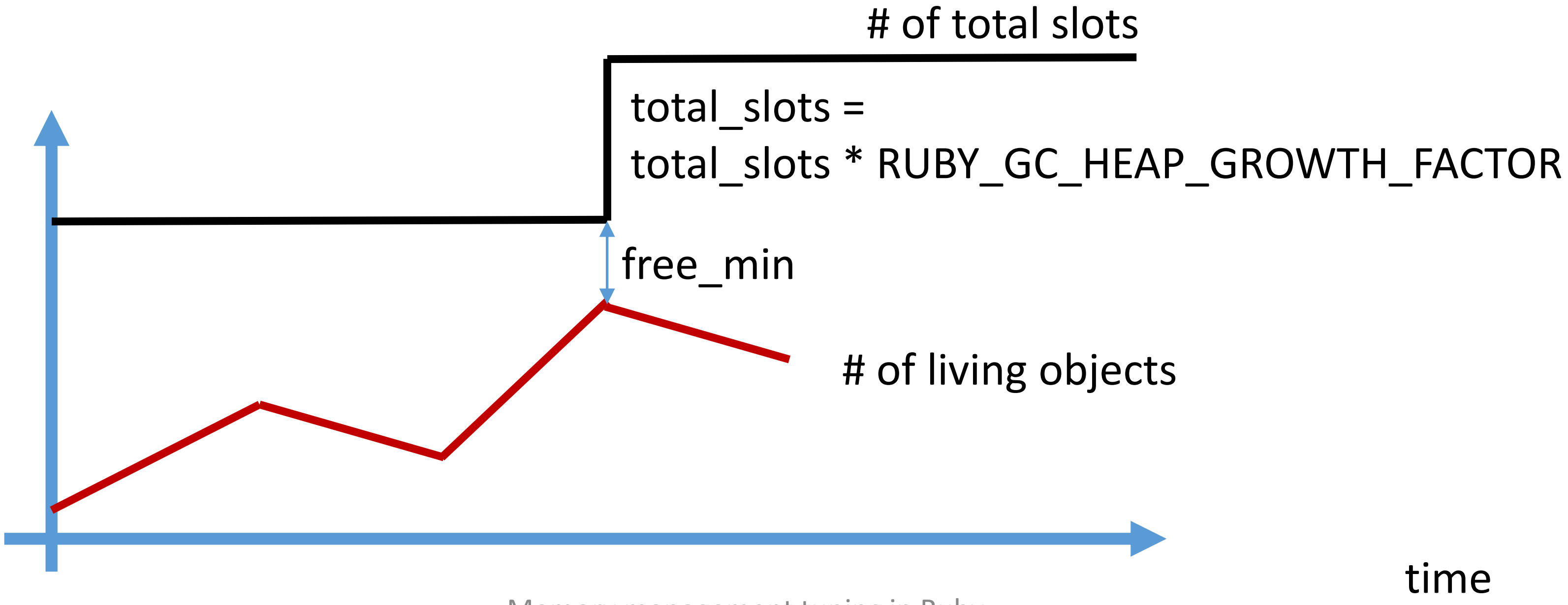
GC_HEAP_INIT/FREE_SLOTS

- RUBY_GC_HEAP_INIT_SLOTS (default: 10000)
  - How many slots prepared at initialize
- RUBY_GC_HEAP_FREE_SLOTS (default: 4096)
  - At least how many slots are available after GC
  - free_min = max(RUBY_GC_HEAP_FREE_SLOTS , total_slots * 0.3)



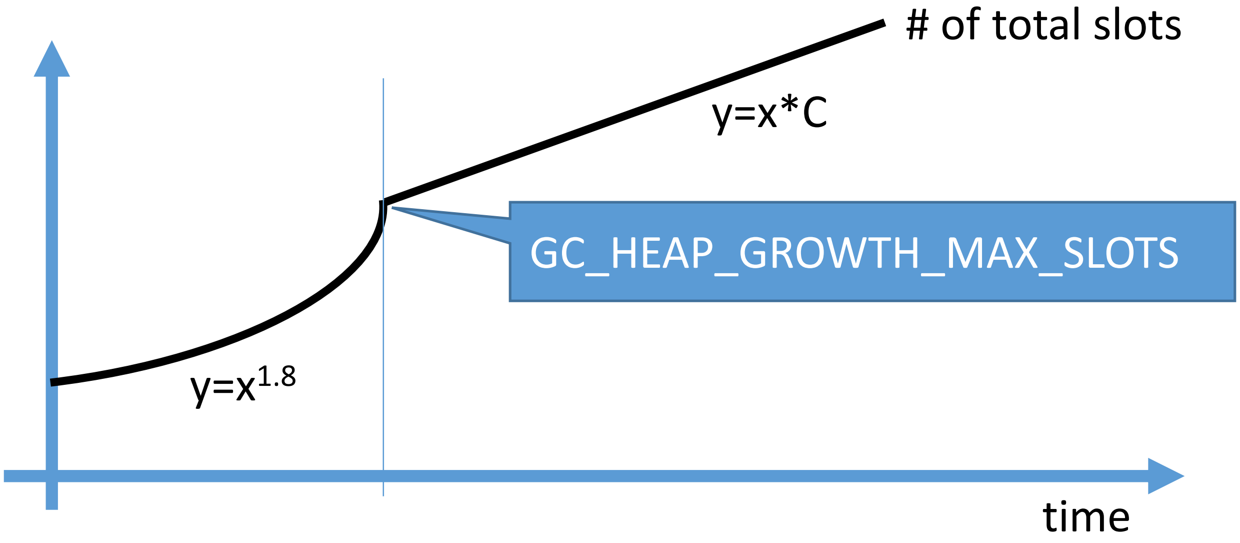
RUBY_GC_HEAP_GROWTH_FACTOR (new from 2.1)

- RUBY_GC_HEAP_GROWTH_FACTOR (default: 1.8)
  - Growth factor of expanding object space
  - Grow object space exponentially to reduce GC time



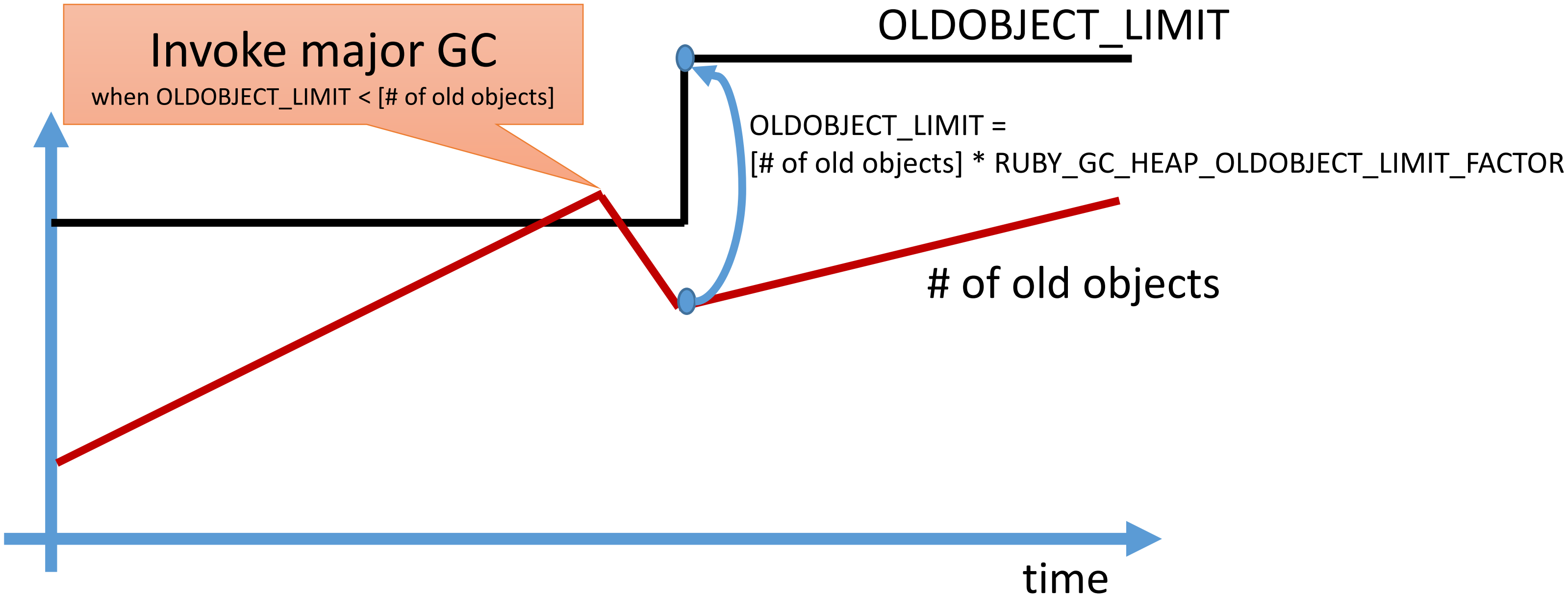
GC_HEAP_GROWTH_MAX_SLOTS (new from Ruby 2.1)

- GC_HEAP_GROWTH_MAX_SLOTS (default: 0)
  - Stop exponential expanding, start linear expanding
  - The value “0” remove this cap



RUBY_GC_HEAP_OLDOBJECT_LIMIT_FACTOR (from Ruby 2.1.1)

- RUBY_GC_HEAP_OLDOBJECT_LIMIT_FACTOR
  - Default value: 2.0
  - Tuning major (full) GC frequency
    - Bigger value: rare, Smaller value: frequent
    - < 1.0: Every GC will be major (full) GC



Invoke major GC
when OLDOBJECT_LIMIT < [# of old objects]

OLDOBJECT_LIMIT

OLDOBJECT_LIMIT =
[# of old objects] * RUBY_GC_HEAP_OLDOBJECT_LIMIT_FACTOR

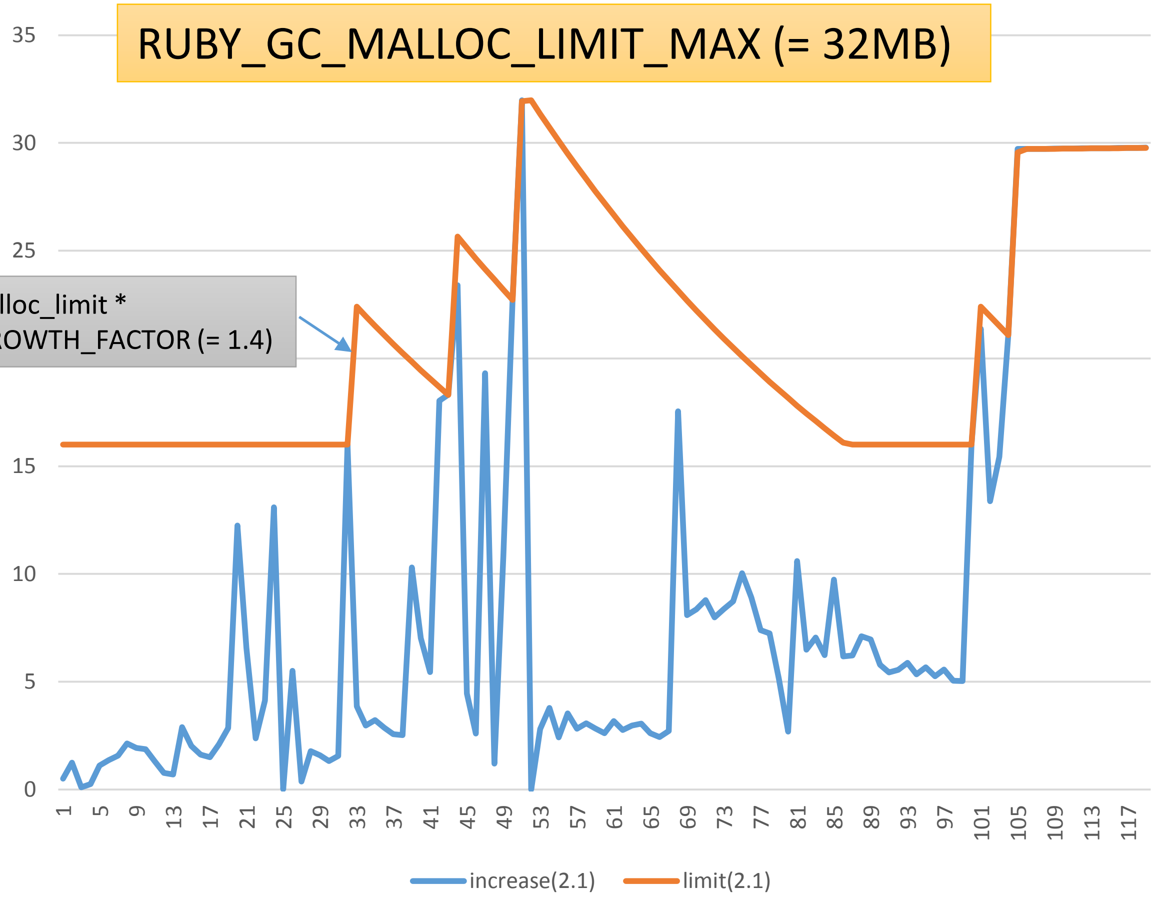
# of old objects

time

RUBY_GC_MALLOC_LIMIT(…)

- RUBY_GC_MALLOC_LIMIT (default: 16MB)
  - Initial value of “malloc_limt”
  - Tuning GC frequency
    - Bigger: rare → High throughput, but consumes memory
    - Smaller: frequent → Low throughput, small memory
- RUBY_GC_MALLOC_LIMIT_MAX (default: 32MB)
  - Maximum value of “malloc_limit”
- RUBY_GC_MALLOC_LIMIT_GROWTH_FACTOR (default: 1.4)
  - Growth ratio of “malloc_limit”

RUBY_GC_MALLOC_LIMIT(...)



RUBY_GC_MALLOC_LIMIT_MAX (= 32MB)

malloc_limit = malloc_limit *
RUBY_GC_MALLOC_LIMIT_GROWTH_FACTOR (= 1.4)

RUBY_GC_MALLOC_LIMIT
(= 16MB)

RUBY_GC_OLDMALLOC_LIMIT(...)

- RUBY_GC_OLDMALLOC_LIMIT (default: 16MB)
- RUBY_GC_OLDMALLOC_LIMIT_MAX (default: 128MB)
- RUBY_GC_OLDMALLOC_LIMIT_GROWTH_FACTOR (default: 1.2)

- Similar to RUBY_GC_MALLOC_LIMIT(…), but parameter for major (full) GC timing

4th question

How to use tuning parameters?

How to use tuning parameters?

1. Profile your application
2. Try GC parameters (environment variables)

http://www.flickr.com/photos/nasa_goddard/5188180370

Profile memory management GC.stat (MRI specific)

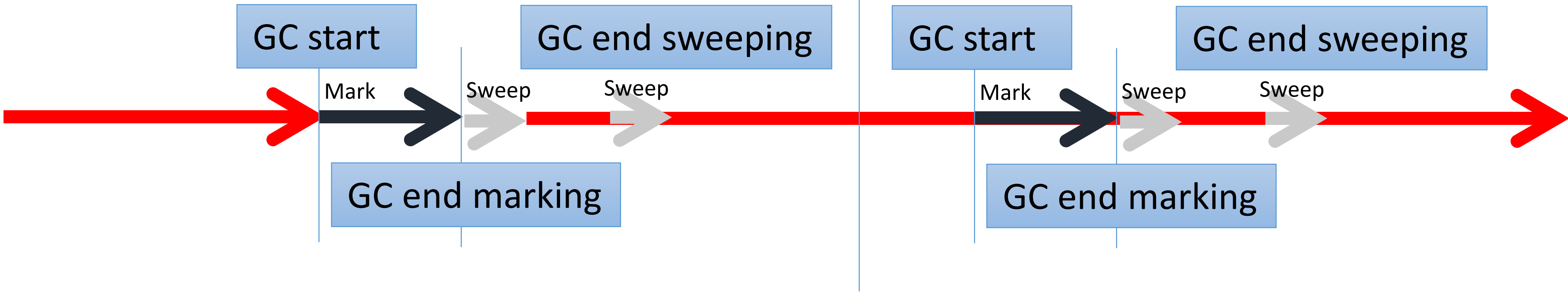
- “GC.stat” returns statistics information about GC
  - Counts
    - :count=>2,   # GC count
    - :minor_gc_count=>2,   # minor GC count
    - :major_gc_count=>0,   # major GC count
  - Current slot information
    - :heap_live_slot=>6836, #=> # of live objects
    - :heap_free_slot=>519, #=> # of freed objects
    - :heap_final_slot=>0,   #=> # of waiting finalizer objects
    - total_slots = heap_live_slot + heap_free_slot + heap_final_slot
  - Statistics
    - :total_allocated_object=>7674,   # total allocated objects
    - :total_freed_object=>838,   # total freed objects
    - Current living objects = total_allocated_object - total_freed_object

Profile memory management GC.latest_gc_info (MRI specific)

- “GC.latest_gc_info” returns details of latest GC
  - **:gc_by=>:newobj   # why GC invoked?**
    - newobj: no slots available
    - malloc: malloc_increase > malloc_limit
  - :major_by=>nil   # why major GC invoked?
  - :have_finalizer=>false   # have finalizer?
  - :immediate_sweep=>false   # immediate sweep?

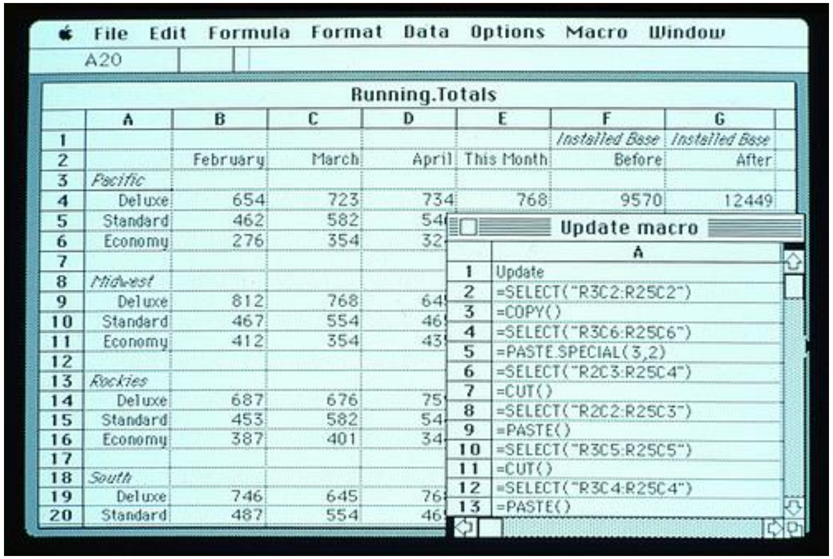
Profile memory management “gc_tracer” gem (MRI 2.1.0 later!!)

- GC::Tracer.start_logging(filename)
  - Save all GC.stat/GC.latest_gc_info results at every GC events into specified file
  - GC events:
    - Start
    - End marking
    - End sweeping



Profile memory management “gc_tracer” gem

- Run your application with gc_tracer
- Plot with Excel!



Running.Totals

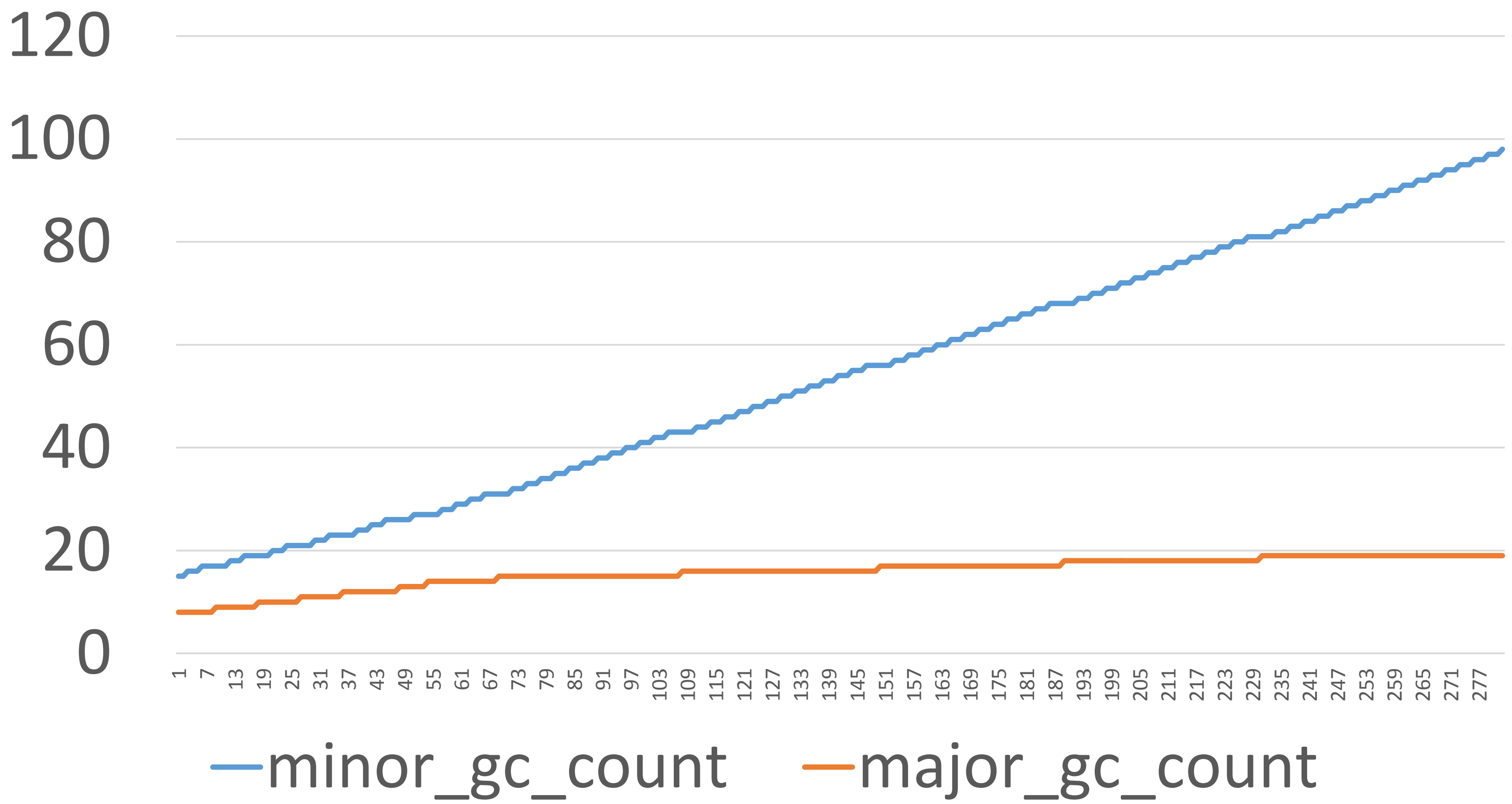
	A	B	C	D	E	F	G
1						*Installed Base*	*Installed Base*
2		February	March	April	This Month	Before	After
3	*Pacific*						
4	Deluxe	654	723	734	768	9570	12449
5	Standard	462	582	54			
6	Economy	276	354	32			
7							
8	*Midwest*						
9	Deluxe	812	768	64			
10	Standard	467	554	46			
11	Economy	412	354	43			
12							
13	*Rockies*						
14	Deluxe	687	676	75			
15	Standard	453	582	54			
16	Economy	387	401	34			
17							
18	*South*						
19	Deluxe	746	645	76			
20	Standard	487	554	46			

Update macro

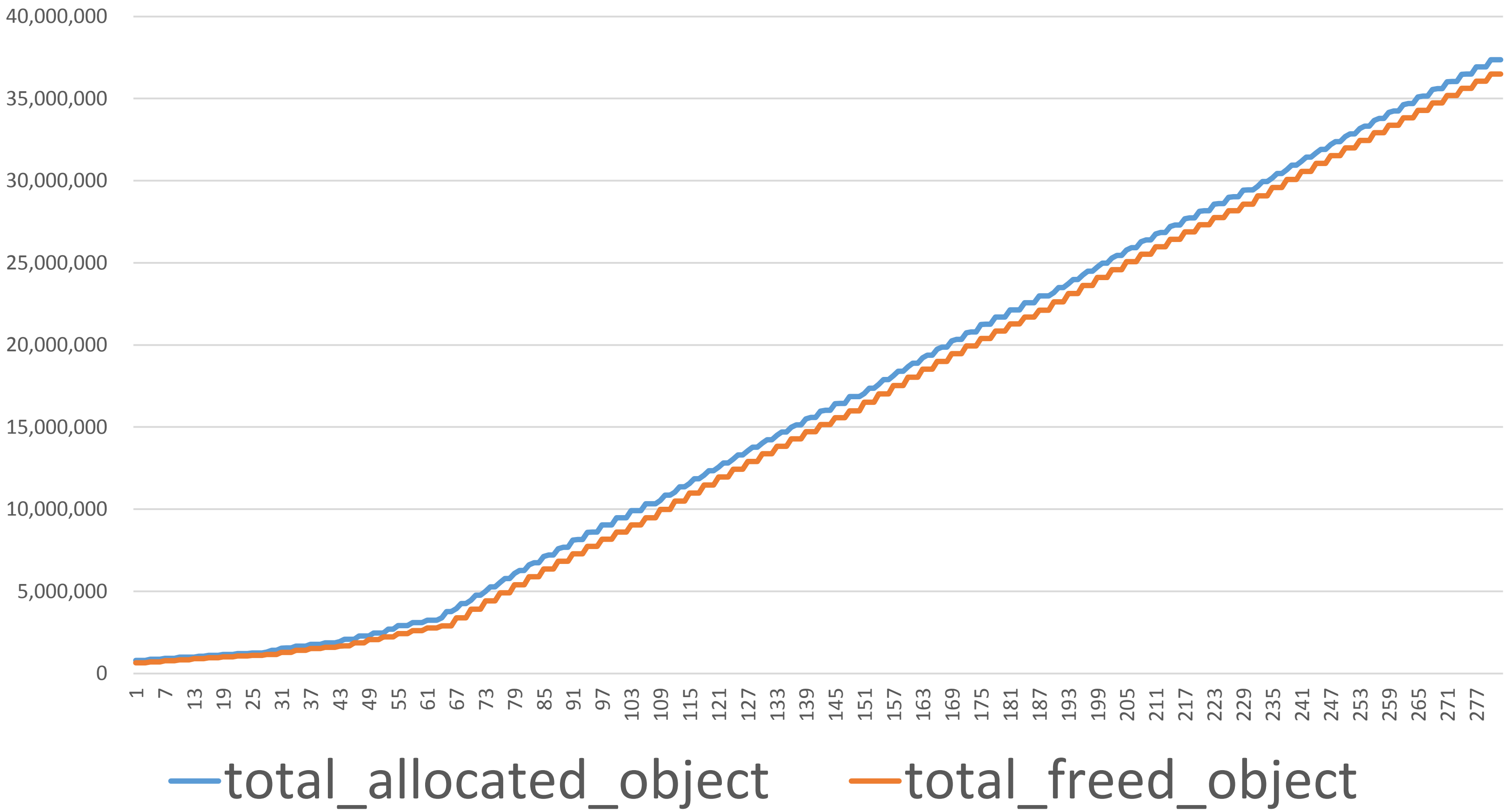
	A
1	Update
2	=SELECT("R3C2:R25C2")
3	=COPY()
4	=SELECT("R3C6:R25C6")
5	=PASTE.SPECIAL(3,2)
6	=SELECT("R2C3:R25C4")
7	=CUT()
8	=SELECT("R2C2:R25C3")
9	=PASTE()
10	=SELECT("R3C5:R25C5")
11	=CUT()
12	=SELECT("R3C4:R25C4")
13	=PASTE()

http://www.flickr.com/photos/microsoftsweden/5394685465

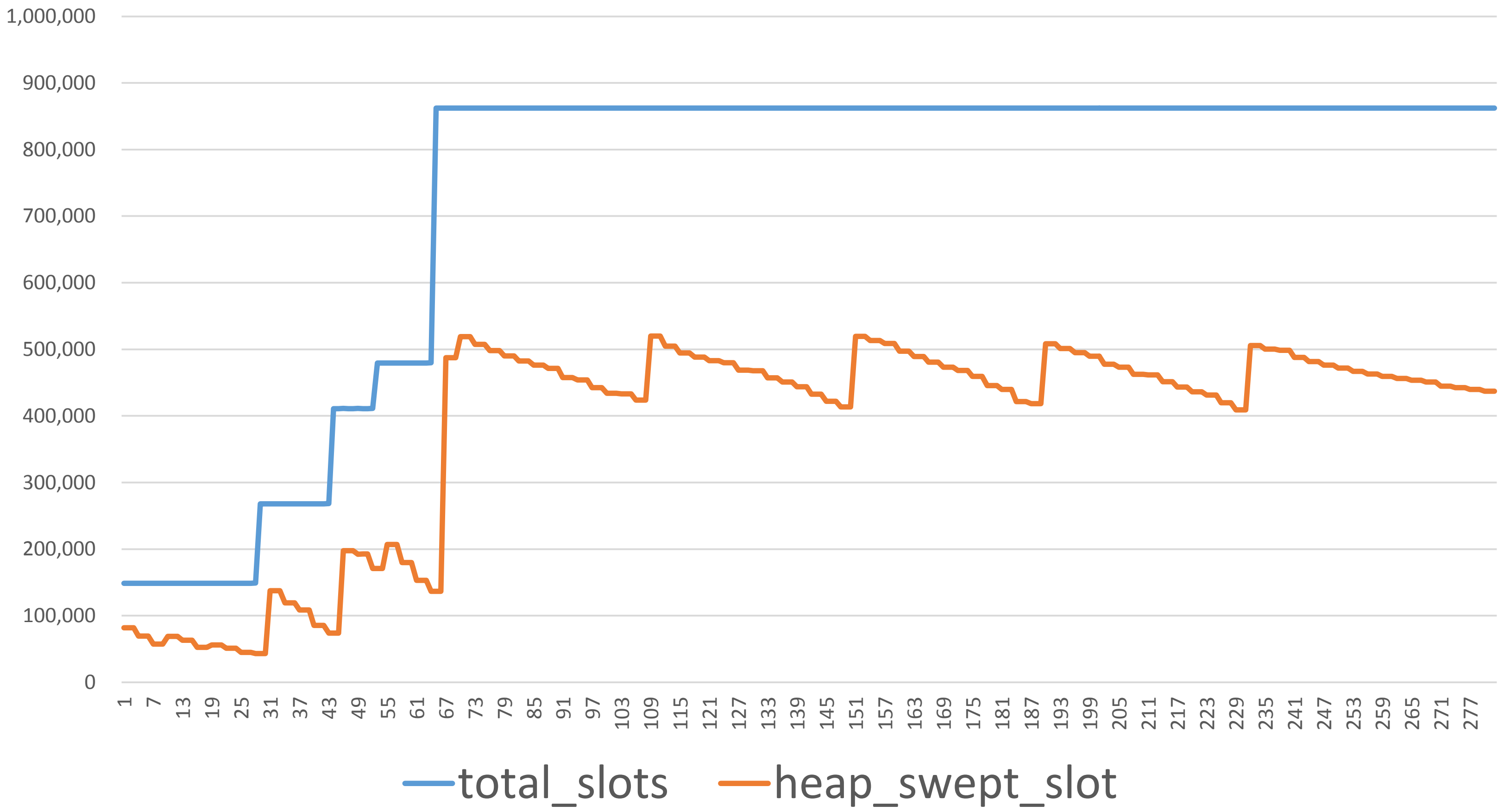
Profile memory management "gc_tracer" gem



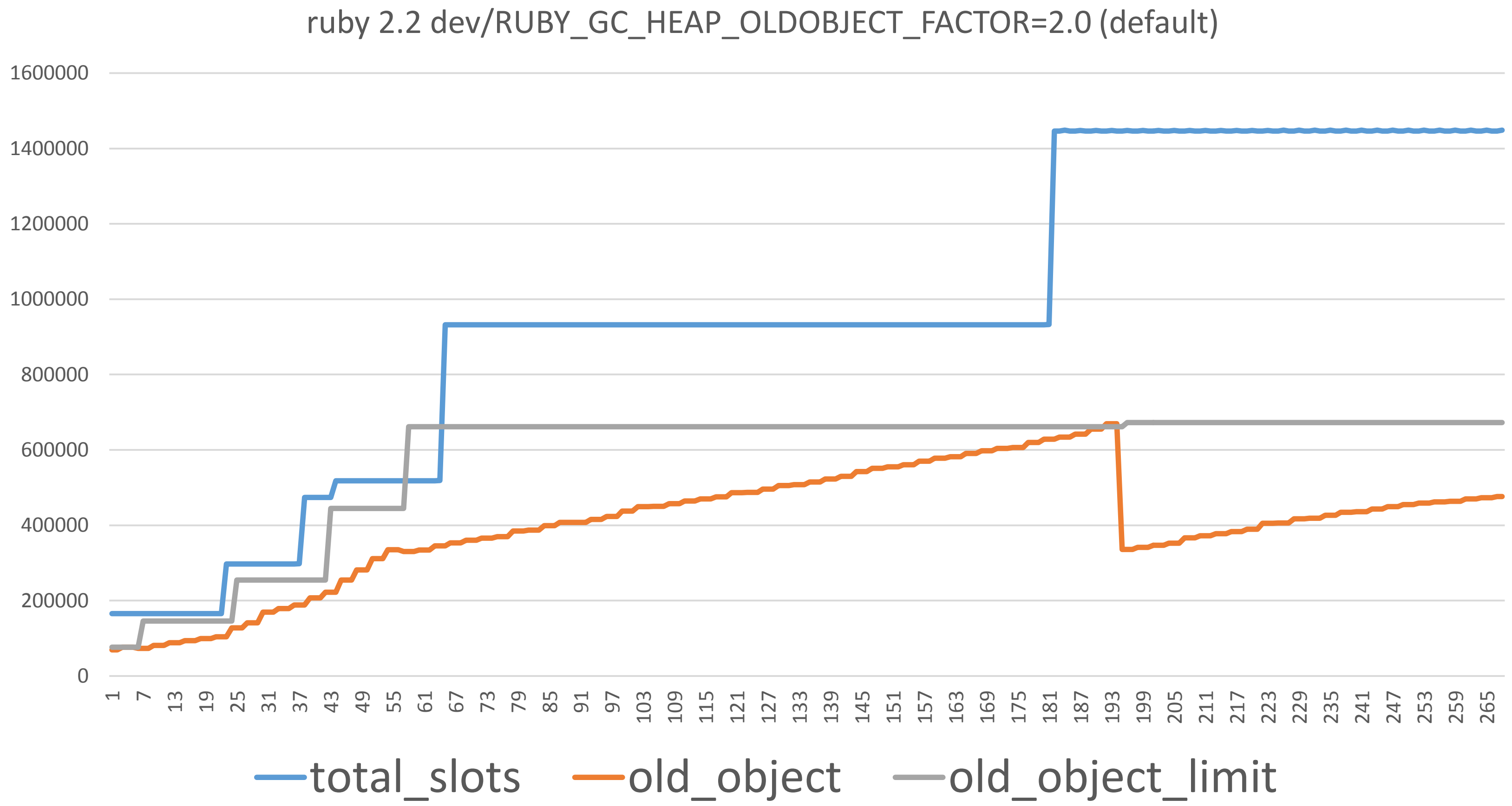
Profile memory management "gc_tracer" gem



Profile memory management “gc_tracer” gem

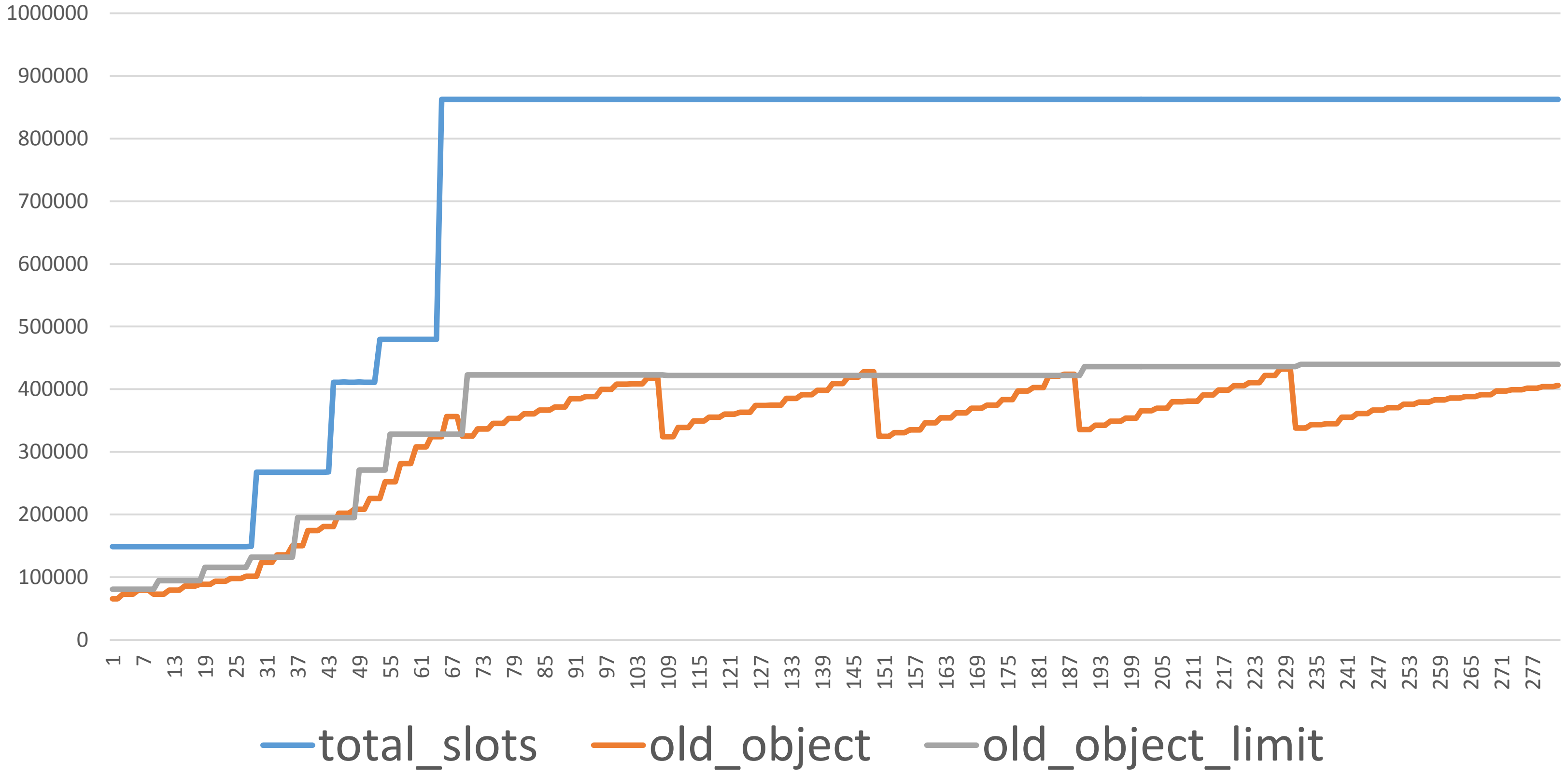


Profile memory management “gc_tracer” gem



Profile memory management "gc_tracer" gem

Ruby 2.2dev w/ RUBY_GC_HEAP_OLDOBJECT_FACTOR=1.3



Try GC parameters

- General concept

Speed <-> Memory trade-off

- You have huge memory

→ Increase parameters to improve performance

  - RUBY_GC_HEAP_INIT_SLOTS (initial slots)
  - RUBY_GC_HEAP_FREE_SLOTS (prepared free slots after GC)
  - RUBY_GC_MALLOC_LIMIT (reduce GC frequency)

Try GC parameters

- You have small memory

Reduce parameters to reduce memory usage

- IaaS, PaaS environments (ex: Heroku 1X dyno (512MB))
- RUBY_GC_HEAP_GROWTH_FACTOR (heap expanding factor)
- **RUBY_GC_HEAP_OLDOBJECT_LIMIT_FACTOR (for more full GC)**
  - If you have memory usage trouble when migrating from 2.0 to 2.1, please try to reduce this variable

Advertisement

Or you can try
Heroku 2X dyno (1GB) / PX dyno (6GB)!!

Try GC parameters

- There is no silver bullet
  - No one answer for all applications
  - You should not believe other applications settings easily
- Try and try and try!

http://www.flickr.com/photos/rowanbank/8483526808

See also

- Excellent blog articles by @tmm1
  - http://tmm1.net/
- Demystifying the Ruby GC by Sam Saffron
  - http://samsaffron.com/archive/2013/11/22/demystifying-the-ruby-gc
- Why I am excited about Ruby 2.1? by Sam Saffron
  - https://speakerdeck.com/samsaffron/why-ruby-2-dot-1-excites-me
  - http://vimeo.com/89491942

Summary of this talk

- New versions
  - Ruby 2.1 (released)
  - Ruby 2.2 (currently working on)
- Basic of Ruby's memory management (GC)
- GC tuning parameters
  - **"What"** and **"How"** we can tune by GC parameters

Thank you for your attention
Q&A?

Koichi Sasada

<ko1@heroku.com>