Ruby master - Bug #17030
Enumerable#grep{_v} should be optimized for Regexp
07/13/2020 08:26 PM - marcandre (Marc-Andre Lafortune)

<table>
<thead>
<tr>
<th>Status:</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority:</td>
<td>Normal</td>
</tr>
<tr>
<td>Assignee:</td>
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<td>Target version:</td>
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<td>Backport:</td>
<td>2.5: UNKNOWN, 2.6: UNKNOWN, 2.7: UNKNOWN</td>
</tr>
</tbody>
</table>

**Description**

Currently,

```ruby
array.select { |e| e.match?(REGEXP) }
```

is about three times faster and six times more memory efficient than

```ruby
array.grep(REGEXP)
```

This is because grep calls Regexp#===, which creates useless MatchData.

**Associated revisions**

Revision d5f0d338 - 12/15/2020 05:54 PM - Marc-Andre Lafortune
Optimize Enumerable#grep{_v}

[Bug #17030]

**History**

#1 - 07/13/2020 08:27 PM - marcandre (Marc-Andre Lafortune)

Code to reproduce by fatkodima (Dima Fatko):

```ruby
require 'benchmark-ips'
require 'benchmark-memory'
arr = %w[foobar foobaz bazquux hello world just making this array longer]
REGEXP = /o/
def select_match(arr)
  arr.select { |e| e.match?(REGEXP) }
end
def grep(arr)
  arr.grep(REGEXP)
end
Benchmark.ips do |x|
  x.report("select.match?") { select_match(arr) }
  x.report("grep") { grep(arr) }
  x.compare!
end
puts "******* MEMORY *******"
```

#2 - 07/14/2020 01:24 AM - shyouhei (Shyouhei Urabe)

Yes but E#grep's allocating MatchData is by spec. You can observe $& etc. by passing a block to it.
p %w[q w e r].grep(/.\/) { $~ }

So this is at least a breaking change.

#3 - 07/14/2020 03:37 AM - marcandre (Marc-Andre Lafortune)
You are right for grep with a block, we can't necessarily optimize, but we should optimize grep without a block, no?

#4 - 07/14/2020 10:25 AM - nobu (Nobuyoshi Nakada)
Even without a block, grep sets $\sim$ to the last match result.

#5 - 07/14/2020 01:28 PM - Eregon (Benoit Daloze)
nobu (Nobuyoshi Nakada) wrote in #note-4:

    Even without a block, grep sets $\sim$ to the last match result.

I guess cases using $\sim$ after the call to grep are very rare (notably because only the last match of the Enumerable would be accessible).

So I would suggest not setting $\sim$ for grep without block.

#6 - 07/14/2020 01:46 PM - marcandre (Marc-Andre Lafortune)
nobu (Nobuyoshi Nakada) wrote in #note-4:

    Even without a block, grep sets $\sim$ to the last match result.

I agree with Eregon (Benoit Daloze), doesn't seem like it makes much sense to use that.

There's also no valid reason it should set $\sim$ for all the matches tested before the last one.

#7 - 07/21/2020 11:27 AM - scivola20 (sciv ola)
I have an idea to solve it without any compatibility problem.

[1] Introduce such a Regexp object that $==$ method is same as match?.
[2] Introduce regexp literal option that makes the Regexp object as [1].

If the option is 'f', we can write as /o/f, and grep(/o/f) is faster than grep(/o/).

This speed up not only grep but also all?, any?, case and so on.

Many people have written like this:

```ruby
IO.foreach("foo.txt") do |line|
  case line
  when /^#/  # do nothing
    when /(^\d+)/  # using $1
      when /xxx/  # using $2
    when /yyy/  # not using $2
      else
        # ...
    end
  end
end
```

This is slow because of the above mentioned problem. Replacing /^#/ with /^#/f, and /yyy/ with /yyy/f will make it faster.

#8 - 08/25/2020 05:23 PM - fatkodima (Dima Fatko)
I like scivola20 (sciv ola)'s idea and would like to try to implement it. Before starting, nobu (Nobuyoshi Nakada), wdyt, is this something that will be merged?

#9 - 08/25/2020 10:09 PM - fatkodima (Dima Fatko)
I have implemented a simple PoC - https://github.com/ruby/ruby/pull/3455.

I got the following results.
Enumerable#grep

ARR = tw[foobar foobaz bazquux hello world just making this array longer]

REGEXP = /o/
FAST_REGEXP = /o/f

Benchmark.ips do |x|
  x.report("select.match?") { ARR.select { |e| e.match?(REGEXP) } }
  x.report("grep") { ARR.grep(REGEXP) }
  x.report("fast_grep") { ARR.grep(FAST_REGEXP) }
  x.compare!

end

puts "********* MEMORY *********

Benchmark.memory do |x|
  x.report("select.match?") { ARR.select { |e| e.match?(REGEXP) } }
  x.report("grep") { ARR.grep(REGEXP) }
  x.report("fast_grep") { ARR.grep(FAST_REGEXP) }
  x.compare!

end

Warming up --------------------------------------
select.match?    57.956k i/100ms
grep              22.715k i/100ms
fast_grep        59.434k i/100ms
Calculating -------------------------------------
select.match?    580.339k (± 0.5%) i/s - 2.956M in 5.093260s
grep              225.854k (± 0.6%) i/s - 1.136M in 5.028890s
fast_grep        532.658k (± 9.0%) i/s - 2.675M in 5.067008s

Comparison:
select.match?: 580338.8 i/s
fast_grep: 532658.1 i/s - same-ish: difference falls within error
grep: 225853.7 i/s - 2.57x (± 0.00) slower

********* MEMORY *********
Calculating -------------------------------------
select.match?: 120.000 memsize ( 0.000 retained)
  1.000 objects ( 0.000 retained)
  0.000 strings ( 0.000 retained)
grep         536.000 memsize (168.000 retained)
  3.000 objects ( 1.000 retained)
  0.000 strings ( 0.000 retained)
fast_grep    200.000 memsize ( 0.000 retained)
  1.000 objects ( 0.000 retained)
  0.000 strings ( 0.000 retained)

Comparison:
select.match?: 120 allocated
fast_grep: 200 allocated - 1.67x more
grep: 536 allocated - 4.47x more

case-when

REGEXP = /z/
FAST_REGEXP = /z/f

def case_when(str)
  case str
    when REGEXP
      true
    end
end

def fast_case_when(str)
  case str
    when FAST_REGEXP
      true
    end
end

STR = 'foobaz'

03/14/2022
Benchmark.ips do |x|
  x.report("case_when") { case_when(STR) }
  x.report("fast_case_when") { fast_case_when(STR) }
  x.compare!
end

puts "********* MEMORY *********

Benchmark.memory do |x|
  x.report("case_when") { case_when(STR) }
  x.report("fast_case_when") { fast_case_when(STR) }
  x.compare!
end

Warming up --------------------------------------
case_when  95.463k i/100ms
fast_case_when  456.981k i/100ms

Calculating -------------------------------------
case_when  964.438k (± 0.8%) i/s -  4.869M in  5.048469s
fast_case_when  4.571M (± 0.6%) i/s - 23.306M in  5.098414s

Comparison:
  fast_case_when:  4571379.8 i/s
  case_when:  964438.3 i/s - 4.74x  (± 0.00) slower

********* MEMORY *********

Calculating -------------------------------------
case_when 168.000 memsize ( 168.000 retained)
          1.000 objects (  0.000 retained)
          0.000 strings (  0.000 retained)
fast_case_when 0.000 memsize (   0.000 retained)
          0.000 objects (   0.000 retained)
          0.000 strings (   0.000 retained)

Comparison:
  fast_case_when: 0 allocated
  case_when: 168 allocated - Infx more

Enumerable#any?

REGEXP = /longer/;
FAST_REGEXP = /longer/f
ARR = %w[foobar foobaz bazquux hello world just making this array longer]

Benchmark.ips do |x|
  x.report("any?") { ARR.any?(REGEXP) }
  x.report("fast_any?") { ARR.any?(FAST_REGEXP) }
  x.compare!
end

puts "********* MEMORY *********

Benchmark.memory do |x|
  x.report("any?") { ARR.any?(REGEXP) }
  x.report("fast_any?") { ARR.any?(FAST_REGEXP) }
  x.compare!
end

Warming up --------------------------------------
any?      25.840k i/100ms
fast_any? 95.381k i/100ms

Calculating -------------------------------------
any? 261.095k (± 1.0%) i/s - 1.318M in  5.047859s
fast_any? 893.676k (±13.2%) i/s - 4.388M in  5.070820s

Comparison:
  fast_any?: 893675.9 i/s
  any?: 261095.0 i/s - 3.42x  (± 0.00) slower

********* MEMORY *********

Calculating -------------------------------------
any? 168.000 memsize ( 168.000 retained)
          1.000 objects (  1.000 retained)
          0.000 strings (  0.000 retained)
I feel sci2020 (sciv ola)'s idea promising, but have a concern that it is going to introduce the same kind of mess as when "string"? notation was introduced (same "f" used due to frozen and fast, but this is just coincidental). People are going to need to write /regex/f all over the place.

Just by analogy from the situation with strings, what about introducing the following pragma, which will make all regex literals on that page fast regex literals (i.e., === becomes match)?

```ruby
# boolean_regex_literal: true
```

And perhaps in the long run, Matz might want to make all regexes work like that, or simply change the definition of Regexp#==.

Yes, seems like this will solve the problem of typing regex/f all over. However, imo, this is not as big problem as for strings, considering regexes to strings amount ratio. Does it also mean that we then should have something like in frozen string world (String#@+) to manually change to the old behavior where we need it, like

```ruby
# boolean_regex_literal: true

case var
  when /foo/
    # does not set $~, etc
  when /bar/
    # sets $~, etc
end
```

Maybe it would be best to start a different thread as none of these proposals have a relation to grep{_v} without block not being optimized.

```

# boolean_regex_literal: true

```

Maybe it would be best to start a different thread as none of these proposals have a relation to grep{_v} without block not being optimized.

I have already implemented a patch to make grep{_v} faster and right before submitting the Create Pull Request button, I realized (with the help of sci2020's comment), that this case can be generalized. Because we already have, at least, Enumerable#(all?, any?, none?) and many future methods to be added (like grep), which can benefit from this generalized solution.

This is Ruby, so I can think of some corner cases where things like const_get(:Regexp).last_match would be impacted (in theory), what other limitations would this have?
case-when?

  Couldn't static analysis of the code determine in most cases if match data need be generated or not?

In many cases, probably yes, but again, case-when, when arguments/consts/etc instead of local vars are used - it is hard to tell if them are regexes or not.

#14 - 08/26/2020 05:30 PM - marcandre (Marc-Andre Lafortune)
fatkodima (Dima Fatko) wrote in #note-13:

  In many cases, probably yes, but again, case-when, when arguments/consts/etc instead of local vars are used - it is hard to tell if them are regexes or not.

That's not really what I'm proposing. I'm proposing something like an internal Regexp.needs_last_match? that would return true or false depending on the Ruby code, and that could be used to optimize methods. It would return true if any subsequent code could be impacted by $~ and al.

```ruby
def foo
  /x/=~'x' # needs_last_match? # => false
  case method
  when /(foo)/ # needs_last_match? # => false
    do_something
  when /(bar)/ # needs_last_match? # => true
    puts $2
    # ... # needs_last_match? # => false
  end
end

def bar
  # ... # needs_last_match? # => true
  case x
  when /(foo)/ # needs_last_match? # => true
    do_something
  end
  Regexp.last_match
  # ... # needs_last_match? # => false (false negative)
  Regexp.send :last_match
  # ... # needs_last_match? # => false (false negative)
  const_get(:Regexp).last_match
end
```

#15 - 08/26/2020 07:17 PM - Dan0042 (Daniel DeLorme)

  Couldn't static analysis of the code determine in most cases if match data need be generated or not?

  scivola20 had a good idea, but this is even better. We can automatically get the best performance without having to manually optimize each case.

  But static analysis has other limits besides const_get(:Regexp).last_match

```ruby
def foo(v)
  /x/=~'x' # needs_last_match? depends on whether 'v' is regexp
  case method
  when v
    $1
  end
end
```

So a simpler approach would be to check if the match operation's scope (in this case the method body) contains any of the regexp-related pseudo-globals.

#16 - 08/26/2020 07:31 PM - marcandre (Marc-Andre Lafortune)

  Dan0042 (Daniel DeLorme) wrote in #note-15:

  But static analysis has other limits

  Good example but it is easily resolved: assume v isn't a Regexp and we may get a false positive, which is not a big issue. There will be other false positives: str.gsub(regexp, &block). That's not a real issue, simply assume that block will want access to Regexp.last_match. I'm really only worried
about false negatives... Any other example comes to mind?

#17 - 08/26/2020 08:43 PM - Dan0042 (Daniel DeLorme)

What about this?

```
2.times do
  p $~ # depends on match *below*
  rx =~ str
end
```

Now imagine if 2.times is replaced by foo; a priori we can't know if or how many times the block will be executed. So what I was trying to say is that flow control can lead to all kinds of code paths where it's extremely difficult to know which matching operations a pseudo-global may depend on. Maybe not impossible, but personally I wouldn't want to code that kind of analysis when a simple approach is enough for >90% of cases, and guaranteed to be bug-free.

There will be other false positives: str.gsub(regexp, &block). That's not a real issue, simply assume that block will want access to Regexp.last_match.

Actually... block does not have access to Regexp.last_match (unless you created the block in the same scope as the gsub operation, but that would be unusual)

#18 - 08/27/2020 01:37 AM - sawa (Tsuyoshi Sawada)

- Description updated

#19 - 08/27/2020 02:10 AM - marcandre (Marc-Andre Lafortune)

Dan0042 (Daniel DeLorme) wrote in #note-17:

Maybe not impossible, but personally I wouldn't want to code that kind of analysis when a simple approach is enough for >90% of cases, and guaranteed to be bug-free.

Agreed

There will be other false positives: str.gsub(regexp, &block). That's not a real issue, simply assume that block will want access to Regexp.last_match.

Actually... block does not have access to Regexp.last_match (unless you created the block in the same scope as the gsub operation, but that would be unusual)

You are right, my bad.

#20 - 08/27/2020 08:03 AM - fatkodima (Dima Fatko)

Dan0042 (Daniel DeLorme) wrote in #note-15:

So a simpler approach would be to check if the match operation's scope (in this case the method body) contains any of the regexp-related pseudo-globals.

I didn't quite get it. So, to summarize, how this new approach should work? Can you elaborate in few more sentences?

Does ruby already do some kind of static analysis that you can point me to?

#21 - 08/27/2020 04:55 PM - Dan0042 (Daniel DeLorme)

Yeah ok, that sentence wasn't very clear, sorry.

The first thing is that when compiling a method to an iseq, you have to set a flag on the iseq if the method contains any of the "last_match" pseudo-globals ($~, $&,$1, Regexp.last_match, ...)

Then in rb_reg_match (aka Regexp#=~), you check if the current iseq has the flag set. This is similar to how rb_backref_get gets the last_match object from execution context > control frame > normal control frame > ep > svar > backref. If the flag is not set it means you can use a variant of reg_match_pos that only returns the position without using rb_reg_search to set the last_match, in the same vein as rb_reg_match_m_p (aka Regexp#match?).

But I may be missing a few details here, as I don't have a full understanding of the VM.

#22 - 08/27/2020 05:16 PM - jeremyevans0 (Jeremy Evans)
Dan0042 (Daniel DeLorme) wrote in #note-21:

Yeah ok, that sentence wasn't very clear, sorry.

The first thing is that when compiling a method to an iseq, you have to set a flag on the iseq if the method contains any of the "last_match" pseudo-globals ($~, $&, $1, Regexp.last_match, ...)

Then in rb_reg_match (aka Regexp#=~), you check if the current iseq has the flag set. This is similar to how rb_backref_get gets the last_match object from execution context > control frame > normal control frame > ep > svar > backref. If the flag is not set it means you can use a variant of reg_match_pos that only returns the position without using rb_reg_search to set the last_match, in the same vein as rb_reg_match_m_p (aka Regexp#match?).

But I may be missing a few details here, as I don't have a full understanding of the VM:

Unfortunately, you can't take this approach for VM optimizations without breaking backwards compatibility unless you also have a deoptimization approach that will handle code such as:

```ruby
def a; /(a)/ =~ 'a'; binding; end; a.eval('$1')
def a; /(a)/ =~ 'a'; proc(); end; a.binding.eval('$1')
def a(c, m); /(a)/ =~ 'a'; c.send(m); end; a(Regexp, :last_match)
```

#23 - 08/28/2020 03:01 PM - Eregon (Benoit Daloze)

This is something that a JIT with inlining and escape analysis can optimize and always be correct. Static analysis doesn't cut it for Ruby.

On TruffleRuby (master + a fix I'll merge soon) for the benchmark above: https://gist.github.com/eregon/998ecc6c4e18ee1dca8c71b23eeb934c

Calculating -------------------------------------
| select.match?       | 2.503M (± 2.9%) i/s - 12.677M in 5.068796s |
| grep                | 2.502M (± 2.8%) i/s - 12.558M in 5.022837s  |
| select.match?       | 2.519M (± 2.6%) i/s - 12.677M in 5.036105s  |
| grep                | 2.498M (± 2.2%) i/s - 12.558M in 5.030485s  |

Comparison:

| select.match?:      | 2518943.6 i/s |
| grep                | 2497618.0 i/s - same-ish: difference falls within error |

MRI 2.6 for comparison:

Calculating -------------------------------------
| select.match?:      | 943.017k (± 0.6%) i/s - 4.770M in 5.058962s |
| grep                | 470.844k (± 0.8%) i/s - 2.389M in 5.074917s  |
| select.match?:      | 944.326k (± 0.7%) i/s - 4.770M in 5.052020s  |
| grep                | 471.122k (± 2.5%) i/s - 2.389M in 5.074969s  |

Comparison:

| select.match?:      | 944325.5 i/s |
| grep                | 471122.3 i/s - 2.00x (± 0.00) slower |

#24 - 08/28/2020 03:30 PM - Eregon (Benoit Daloze)

I'm surprised at the performance difference on MRI though. Just allocating the MatchData shouldn't be so expensive. Maybe Regexp#match? has additional optimizations?

#25 - 09/25/2020 06:53 AM - matz (Yukihiro Matsumoto)

As far as we measured, there are still plenty of room for the optimization (for example, we don't need to allocate MatchObject for grep_v). We will investigate to improve the performance for those methods.

Besides that, /f flag for regexp may be a useful idea (though little ugly). Could you resubmit the independent issue for the feature, if you like.

Matz.

#26 - 12/15/2020 05:55 PM - Anonymous

- Status changed from Open to Closed

Applied in changeset gitid5f0d338c7b5d3d64929b51d29061d369550e8c4.

03/14/2022 8/9
Optimize Enumerable#grep(_.v)

[Bug #17030]