

## Ruby trunk - Feature #15166

### 2.5 times faster implementation than current gcd implementation

09/26/2018 06:30 PM - jzakiya (Jabari Zakiya)

<b>Status:</b>	Assigned
<b>Priority:</b>	Normal
<b>Assignee:</b>	watson1978 (Shizuo Fujita)
<b>Target version:</b>	
<b>Description</b>	
<p>This is to be more explicit (and accurate) than <a href="https://bugs.ruby-lang.org/issues/15161">https://bugs.ruby-lang.org/issues/15161</a></p> <p>This is my modified gcd benchmarks code, originally presented by Daniel Lemire (see 15161).</p> <p><a href="https://gist.github.com/jzakiya/44eae4feeda8f6b048e19ff41a0c6566">https://gist.github.com/jzakiya/44eae4feeda8f6b048e19ff41a0c6566</a></p> <p>Ruby's current implementation of Stein's gcd algorithm is only slightly faster than the code posted on the wikipedia page, and over 2.5 times slower than the fastest implementation in the benchmarks.</p> <pre>[jzakiya@localhost ~]\$ ./gcdbenchmarks gcd between numbers in [1 and 2000]  gcdwikipedia7fast32 : time = 99 gcdwikipedia4fast   : time = 121 gcdFranke           : time = 126 gcdwikipedia3fast   : time = 134 gcdwikipedia2fastswap : time = 136 gcdwikipedia5fast   : time = 139 gcdwikipedia7fast   : time = 138 gcdwikipedia2fast   : time = 136 gcdwikipedia6fastxchg : time = 144 gcdwikipedia2fastxchg : time = 156 gcd_iterative_mod   : time = 210 gcd_recursive       : time = 215 basicgcd            : time = 211 rubygcd             : time = 267 gcdwikipedia2       : time = 321 gcd between numbers in [1000000001 and 1000002000]  gcdwikipedia7fast32 : time = 100 gcdwikipedia4fast   : time = 121 gcdFranke           : time = 126 gcdwikipedia3fast   : time = 134 gcdwikipedia2fastswap : time = 136 gcdwikipedia5fast   : time = 138 gcdwikipedia7fast   : time = 138 gcdwikipedia2fast   : time = 136 gcdwikipedia6fastxchg : time = 144 gcdwikipedia2fastxchg : time = 156 gcd_iterative_mod   : time = 210 gcd_recursive       : time = 215 basicgcd            : time = 211 rubygcd             : time = 269 gcdwikipedia2       : time = 323</pre> <p>This is Ruby's code per: <a href="https://github.com/ruby/ruby/blob/3abbaab1a7a97d18f481164c7dc48749b86d7f39/rational.c#L285-L307">https://github.com/ruby/ruby/blob/3abbaab1a7a97d18f481164c7dc48749b86d7f39/rational.c#L285-L307</a> which is basically the wikipedia implementation.</p> <pre>inline static long i_gcd(long x, long y) {     unsigned long u, v, t;     int shift;</pre>	

```

if (x < 0)
x = -x;
if (y < 0)
y = -y;

if (x == 0)
return y;
if (y == 0)
return x;

u = (unsigned long)x;
v = (unsigned long)y;
for (shift = 0; ((u | v) & 1) == 0; ++shift) {
u >>= 1;
v >>= 1;
}

while ((u & 1) == 0)
u >>= 1;

do {
while ((v & 1) == 0)
v >>= 1;

if (u > v) {
t = v;
v = u;
u = t;
}
v = v - u;
} while (v != 0);

return (long)(u << shift);
}

```

This is the fastest implementation from the benchmarks. (I originally, wrongly, cited the implementation in the article, which is 4|5th fastest in benchmarks, but still almost 2x faster than the Ruby implementation.)

```

// based on wikipedia's article,
// fixed by D. Lemire, K. Willets
unsigned int gcdwikipedia7fast32(unsigned int u, unsigned int v)
{
int shift, uz, vz;
if ( u == 0) return v;
if ( v == 0) return u;
uz = __builtin_ctz(u);
vz = __builtin_ctz(v);
shift = uz > vz ? vz : uz;
u >>= uz;
do {
v >>= vz;
int diff = v;
diff -= u;
if ( diff == 0 ) break;
vz = __builtin_ctz(diff);
if ( v < u ) u = v;
v = abs(diff);
} while( 1 );
return u << shift;
}

```

The key to speeding up all the algorithms is using the `__builtin_ctz(x)` directive to determine the number of trailing binary '0's.

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## History

### #1 - 09/26/2018 06:34 PM - jzakiya (Jabari Zakiya)

- Backport deleted (2.3: UNKNOWN, 2.4: UNKNOWN, 2.5: UNKNOWN)

- Tracker changed from Bug to Feature

### #2 - 09/26/2018 11:33 PM - mame (Yusuke Endoh)

- Assignee set to watson1978 (Shizuo Fujita)

- Status changed from Open to Assigned

Thanks. Assigned to @watson1978.

It would be very helpful if you could provide us a patch and perform the benchmark with Ruby implementation, not a toy benchmark program. Note that `__builtin_ctzl` is not available on some compilers. You need to check if it is available or not.

### #3 - 09/27/2018 10:37 PM - jzakiya (Jabari Zakiya)

Hi

I just submitted this issue feature request:

<https://bugs.ruby-lang.org/issues/15172>

to deal with the issue of using (or not) the `__builtin_ctz` compiler directive.

I implemented code that mimicked it that also greatly increases the ruby gcd performance. I included the new code and benchmarks to the gist I previously linked.

<https://gist.github.com/jzakiya/44eae4feeda8f6b048e19ff41a0c6566>

```
[jzakiya@jabari-pc ~]$ ./gcd2
gcd between numbers in [1 and 2000]
```

```
gcdwikipedia7fast32 : time = 73
gcdwikipedia4fast   : time = 113
gcdFranke          : time = 133
gcdwikipedia3fast   : time = 139
gcdwikipedia2fastswap : time = 162
gcdwikipedia5fast   : time = 140
gcdwikipedia7fast   : time = 129
gcdwikipedia2fast   : time = 161
gcdwikipedia6fastxchg : time = 145
gcdwikipedia2fastxchg : time = 168
gcd_iterative_mod   : time = 230
gcd_recursive       : time = 232
basicgcd            : time = 234
rubygcd             : time = 305
gcdwikipedia2       : time = 312
gcdwikipedia7fast32_a : time = 129
gcdwikipedia4fast_a : time = 149
rubygcd_a           : time = 193
rubygcd_b           : time = 169
gcd between numbers in [1000000001 and 1000002000]
```

```
gcdwikipedia7fast32 : time = 76
gcdwikipedia4fast   : time = 106
gcdFranke          : time = 121
gcdwikipedia3fast   : time = 127
gcdwikipedia2fastswap : time = 153
gcdwikipedia5fast   : time = 126
gcdwikipedia7fast   : time = 118
gcdwikipedia2fast   : time = 148
gcdwikipedia6fastxchg : time = 134
gcdwikipedia2fastxchg : time = 154
gcd_iterative_mod   : time = 215
gcd_recursive       : time = 214
basicgcd            : time = 220
rubygcd             : time = 287
gcdwikipedia2       : time = 289
gcdwikipedia7fast32_a : time = 116
gcdwikipedia4fast_a : time = 142
```

```
rubygcd_a      : time = 180
rubygcd_b      : time = 155
```

Note using the `__builtin_ctz` mimicking code, instead of the directive itself, still makes the `gcdwikipedia7fast32_a` the third fastest version, and obviously the preferred implementation if not using `__builtin_ctz`.

I present this in asking you how you want me to proceed, because I don't really know C code and how to do PRs to Ruby. If you can lay out a detailed process for me to do that maybe I can assess what is in my capacity to do.

At minimum, the code for `rubygcd_a` could|can be incorporated into the codebase without dealing right now with the `__builtin_ctz` directive issue.

#### #4 - 09/28/2018 12:48 AM - mame (Yusuke Endoh)

No, no. You can just use `__builtin_ctzl` when it is available. All you need is check if it is available or not, and keep the original code for the case where `__builtin_ctzl` is unavailable. Gcc and clang provide it, so it is actually available in almost all cases. Even if `__builtin_ctzl` is unavailable, it should still build and work, but the performance does not matter, I think.

Ruby is already using `__builtin_ctz` and `__builtin_ctzll`. See `configure.ac` and `internal.h`.

#### #5 - 12/28/2018 06:23 PM - ahorek (Pavel Rosický)

your micro-benchmarks aren't always fair, because some algorithms don't handle all edge cases, different data types etc.

for `jruby` I choose a different algorithm that is slightly slower than the fastest `gcdwikipedia7fast32` (~15%) but in my opinion more readable. <https://github.com/jruby/jruby/blob/1d0c3d643a6841f388e646678ee243bf571450c/core/src/main/java/org/jruby/util/Numeric.java#L512>

here's the PR (`gcdwikipedia7fast32` + minor changes) <https://github.com/ruby/ruby/pull/2060>

and some ruby numbers (benchmark <https://github.com/ruby/ruby/pull/1596>)

all variants tested on AMD FX 8300 8C and gcc version 8.1.0 (Ubuntu 8.1.0-5ubuntu1~14.04)  
**ruby 2.7.0dev (2018-12-28 trunk 66617) [x86\_64-linux]**

Time#subsec	2.969M (± 9.6%)	i/s -	14.733M	in	5.010950s
Time#-	5.716M (±11.4%)	i/s -	28.103M	in	5.000934s
Time#round	400.712k (±11.9%)	i/s -	1.992M	in	5.046665s
Time#to_f	6.422M (±10.5%)	i/s -	31.613M	in	4.999488s
Time#to_r	2.251M (±10.4%)	i/s -	11.124M	in	5.002516s
Rational#+	5.377M (±10.1%)	i/s -	26.577M	in	5.001636s
Rational#-	5.542M (± 9.5%)	i/s -	27.419M	in	5.001546s
Rational#*	6.341M (± 9.5%)	i/s -	31.390M	in	5.002212s
gcd	6.922M (± 9.0%)	i/s -	34.285M	in	5.001389s

#### trunk + new gcd

Time#subsec	3.348M (± 8.9%)	i/s -	16.592M	in	4.999620s / 1.13
Time#-	5.840M (±11.6%)	i/s -	28.728M	in	5.000946s / 1.02
Time#round	468.770k (±12.5%)	i/s -	2.319M	in	5.028050s / 1.17
Time#to_f	6.713M (± 9.8%)	i/s -	33.214M	in	4.999639s / 1.05
Time#to_r	3.191M (± 7.9%)	i/s -	15.884M	in	5.010305s / 1.42
Rational#+	5.893M (±10.6%)	i/s -	29.082M	in	4.999884s / 1.10
Rational#-	6.183M (±11.2%)	i/s -	30.443M	in	4.999746s / 1.12
Rational#*	7.069M (±10.5%)	i/s -	34.922M	in	5.001804s / 1.11
gcd	9.742M (±10.4%)	i/s -	48.159M	in	5.007085s / 1.40

#### trunk + new gcd without `__builtin_ctz` support

Time#subsec	2.699M (± 8.9%)	i/s -	13.385M	in	5.002527s / 0.89
Time#-	5.734M (±10.6%)	i/s -	28.224M	in	5.002541s / 1.00
Time#round	392.314k (±13.8%)	i/s -	1.926M	in	5.012040s / 0.98
Time#to_f	6.725M (±10.5%)	i/s -	33.163M	in	4.999346s / 1.04
Time#to_r	2.366M (± 9.1%)	i/s -	11.705M	in	5.004491s / 1.05
Rational#+	5.429M (±10.1%)	i/s -	26.851M	in	5.006358s / 1.01
Rational#-	5.544M (± 9.8%)	i/s -	27.430M	in	5.002418s / 0.98
Rational#*	6.225M (±10.7%)	i/s -	30.833M	in	5.018386s / 0.98
gcd	7.001M (± 7.1%)	i/s -	34.855M	in	5.006972s / 1.01

#### alternative implementations

**jruby 9.2.6.0-SNAPSHOT (2.5.3) 2018-12-27 e51a3e4 Java HotSpot(TM) 64-Bit Server VM 11.0.1+13-LTS on 11.0.1+13-LTS +jit [linux-x86\_64]**

Time#subsec	5.018M (± 6.3%)	i/s -	24.866M	in	4.979170s
Time#-	7.868M (± 5.6%)	i/s -	39.066M	in	4.985576s

Time#round	3.461M (± 8.1%)	i/s -	17.138M in	4.998527s
Time#to_f	8.198M (± 5.2%)	i/s -	40.775M in	4.990224s
Time#to_r	4.789M (± 6.9%)	i/s -	23.777M in	4.992261s
Rational#+	5.217M (± 6.3%)	i/s -	25.944M in	4.995694s
Rational#-	5.701M (± 7.4%)	i/s -	28.329M in	4.998743s
Rational#*	6.290M (± 6.7%)	i/s -	31.283M in	4.997365s
gcd	7.376M (± 7.2%)	i/s -	36.625M in	4.995073s

**truffleruby 1.0.0-rc10, like ruby 2.4.4, GraaIVM CE Native [x86\_64-linux]**

Time#subsec	3.541M (±67.8%)	i/s -	13.706M in	4.986699s
Time#-	8.279M (± 9.4%)	i/s -	38.671M in	4.984896s
Time#round	311.696k (±43.3%)	i/s -	502.226k in	4.991276s
Time#to_f	16.719M (± 9.2%)	i/s -	75.067M in	4.981367s
Time#to_r	1.386M (±21.2%)	i/s -	5.045M in	4.993055s
Rational#+	7.332M (±14.7%)	i/s -	28.100M in	4.982371s
Rational#-	7.354M (±24.3%)	i/s -	22.682M in	4.992218s
Rational#*	7.340M (±19.3%)	i/s -	28.534M in	5.003816s
gcd	68.576M (± 4.7%)	i/s -	326.812M in	4.908116s

as you can see Time#to\_r and Integer#gcd is about 40% faster which is the best case scenario even when in your micro-benchmark it was 300% faster.

using the new algorithm without \_\_builtin\_ctz introduced some perf regressions, but they're within margin of error

I don't think this change will have some impact on real application's performance, all of these cases are just micro-benchmarks...

**#6 - 12/28/2018 06:33 PM - ahorek (Pavel Rosický)**

- File rational.c.patch added

**Files**

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rational.c.patch	1.22 KB	12/28/2018	ahorek (Pavel Rosický)
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