## Why do we may need double dispatch?

In most cases, when writing R scripts or even creating R packages, it is enough to use standard functions or S3 methods. However, there is one important field that forces us to consider **double dispatch** question: **arithmetic operators**.

Suppose we'd like to create a class, which fits the problem we're currently working on. Let's name such class **beer**.

```
<span class="n">beer</span><span class="w"> </span><span class="o">
<-</span><span class="w"> </span><span class="k">function</span><span
class="p">(</span><span class="n">type</span><span class="p">)
{</span><span class="w">
  </span><span class="n">structure</span><span class="p">(</span><span
class="nf">list</span><span class="p">(</span><span
class="n">type</span><span class="w">  </span><span class="o">=
</span><span class="w"> </span><span class="n">type</span><span
class="p">),</span><span class="n">class</span><span class="w">
</span><span class="o">=</span><span class="w"> </span><span
class="s2">"beer"</span><span class="p">)</span><span class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">opener</span><span class="w"> </span><span
class="o"><-</span><span class="w"> </span><span
class="k">function</span><span class="p">(){</span><span class="w">
  </span><span class="n">structure</span><span class="p">(</span><span
class="nf">list</span><span class="p">(),</span><span class="w">
</span><span class="n">class</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span class="s2">"opener"
</span><span class="p">)</span><span class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">pilsner</span><span class="w"> </span><span
class="o"><-</span><span class="w"> </span><span
class="n">beer</span><span class="p">(</span><span class="s2">"pilnser"
</span><span class="p">)</span><span class="w">
</span><span class="n">my_opener</span><span class="w"> </span><span
class="o"><-</span><span class="w"> </span><span
class="n">opener</span><span class="p">()</span><span class="w">
</span>
```

Then, we create an operator which defines some non-standard behaviour.

- if we add an opener to the beer, we get an **opened_beer**.
- adding a **numeric** *x*, we get a case of beers (which even contain a negative number of bees, i.e. our owe…)
- if second argument is different than a or **opener** or **numeric**, we get… untouched beer

Let's demonstrate, how does it work:

```
<span class="n">`+.beer`</span><span class="w"> </span><span class="o">
<-</span><span class="w"> </span><span class="k">function</span><span
class="p">(</span><span class="n">a</span><span class="p">,</span><span
class="w"> </span><span class="n">b</span><span class="p">)
{</span><span class="w">
  </span><span class="k">if</span><span class="w"> </span><span
class="p">(</span><span class="n">inherits</span><span class="p">
(</span><span class="n">b</span><span class="p">,</span><span
class="w"> </span><span class="s2">"opener"</span><span class="p">))
</span><span class="w"> </span><span class="p">{</span><span class="w">
        </span><span class="nf">return</span><span class="p">
(</span><span class="n">structure</span><span class="p">(</span><span
class="nf">list</span><span class="p">(</span><span class="w">
          </span><span class="n">name</span><span class="w">
</span><span class="o">=</span><span class="w"> </span><span
class="n">paste</span><span class="p">(</span><span class="s2">"opened"
</span><span class="p">,</span><span class="w"> </span><span
class="n">a</span><span class="o">$</span><span
class="n">name</span><span class="p">)</span><span class="w">
    </span><span class="p">),</span><span class="w"> </span><span
class="n">class</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"opened_beer"</
span><span class="p">))</span><span class="w">
  </span><span class="p">}</span><span class="w"> </span><span
class="k">else</span><span class="w"> </span><span
class="k">if</span><span class="w"> </span><span class="p">
(</span><span class="n">inherits</span><span class="p">(</span><span
class="n">b</span><span class="p">,</span><span class="w"> </span><span
class="s2">"numeric"</span><span class="p">))</span><span class="w">
</span><span class="p">{</span><span class="w">
    </span><span class="n">print</span><span class="p">(</span><span
class="s2">"It's magic! You've got a case of beers!"</span><span
class="p">)</span><span class="w">
    </span><span class="nf">return</span><span class="p">(</span><span
class="n">structure</span><span class="p">(</span><span
class="nf">list</span><span class="p">(</span><span class="w">
        </span><span class="n">n_beers</span><span class="w">
</span><span class="o">=</span><span class="w"> </span><span
class="m">1</span><span class="w"> </span><span class="o">+</span><span
class="w"> </span><span class="n">b</span><span class="w">
    </span><span class="p">),</span><span class="w"> </span><span
class="n">class</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"case_of_beers"</
span><span class="p">))</span><span class="w">
  </span><span class="p">}</span><span class="w"> </span><span
class="k">else</span><span class="w"> </span><span class="p">
{</span><span class="w">
    </span><span class="nf">return</span><span class="p">(</span><span
class="n">a</span><span class="p">)</span><span class="w">
  </span><span class="p">}</span><span class="w">
</span><span class="p">}</span><span class="w">
</span>
```

```
<span class="n">pilsner</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="n">my_opener</span><span
class="w">
</span>

## $name
## [1] "opened "
##
## attr(,"class")
## [1] "opened_beer"

<span class="n">pilsner</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="m">-0.1</span><span
class="w">
</span>

## [1] "It's magic! You've got a case of beers!"

## $n_beers
## [1] 0.9
##
## attr(,"class")
## [1] "case_of_beers"
```

Don't you think, that such operations should be **commutative**?

```
<span class="n">my_opener</span><span class="w"> </span><span
class="o">+</span><span class="w"> </span><span
class="n">pilsner</span><span class="w">
</span>

## list()
## attr(,"class")
## [1] "opener"
```

What did happen here? This is an example of the way the R interpreter handles arithmetic operator. It was described with details on **Hiroaki Yutani's blog**.
Briefly speaking, in this particular case R engine matched method to the second argument (not to the first one), because there is no `+.opener` S3 method. What about such trick:

```
<span class="n">`+.opener`</span><span class="w"> </span><span
class="o"><-</span><span class="w"> </span><span
class="k">function</span><span class="p">(</span><span
class="n">a</span><span class="p">,</span><span class="w"> </span><span
class="n">b</span><span class="p">)</span><span class="w"> </span><span
class="n">b</span><span class="w"> </span><span class="o">+</span><span
class="w"> </span><span class="n">a</span><span class="w">
</span>
```

After that, the result is different:

```
<span class="n">my_opener</span><span class="w"> </span><span
class="o">+</span><span class="w"> </span><span
class="n">pilsner</span><span class="w">
</span>

## Warning: Incompatible methods ("+.opener", "+.beer") for "+"

## Error in my_opener + pilsner: non-numeric argument to binary
operator
```

We crashed our function call. When both objects have the `+` method defined and these methods are not the same, R is trying to resolve the conflict by applying an internal `+`. It obviously cannot work. This case could be easily solved using more 'ifs' in the `+.beer` beer function body. But let's face a different situation.

```
<span class="m">-0.1</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="n">pilsner</span><span
class="w">
</span>

## [1] -0.1
```

What a mess! Simple S3 methods are definitely not the best solution when we need the double dispatch.

## S4 class: a classic approach

To civilize such code, we can use classic R approach, S4 methods. We'll start from S4 classes declaration.

```
<span class="n">.S4_beer</span><span class="w">          </span><span
class="o"><-</span><span class="w"> </span><span
class="n">setClass</span><span class="p">(</span><span
class="s2">"S4_beer"</span><span class="p">,</span><span class="w">
</span><span class="n">representation</span><span class="p">
(</span><span class="n">type</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span class="s2">"character"
</span><span class="p">))</span><span class="w">
</span><span class="n">.S4_opened_beer</span><span class="w">
</span><span class="o"><-</span><span class="w"> </span><span
class="n">setClass</span><span class="p">(</span><span
class="s2">"S4_opened_beer"</span><span class="p">,</span><span
class="w"> </span><span class="n">representation</span><span class="p">
(</span><span class="n">type</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span class="s2">"character"
</span><span class="p">))</span><span class="w">
</span><span class="n">.S4_opener</span><span class="w">
</span><span class="o"><-</span><span class="w"> </span><span
class="n">setClass</span><span class="p">(</span><span
class="s2">"S4_opener"</span><span class="p">,</span><span class="w">
</span><span class="n">representation</span><span class="p">
(</span><span class="n">ID</span><span class="w"> </span><span
```

```
class="o">=</span><span class="w"> </span><span class="s2">"numeric"
</span><span class="p">))</span><span class="w">
</span><span class="n">.S4_case_of_beers</span><span class="w">
</span><span class="o"><-</span><span class="w"> </span><span
class="n">setClass</span><span class="p">(</span><span
class="s2">"S4_case_of_beers"</span><span class="p">,</span><span
class="w"> </span><span class="n">representation</span><span class="p">
(</span><span class="n">n_beers</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span class="s2">"numeric"
</span><span class="p">))</span><span class="w">
</span>
```

Then, we can two otptions, how to handle + operators. I didn't mention about it in the previous example, but both S3 and S4 operators are grouped as so-called **group generic functions** (learn more: **S3**, **S4**).

We can set a S4 method for a single operator and that looks as follows:

```
<span class="n">setMethod</span><span class="p">(</span><span
class="s2">"+"</span><span class="p">,</span><span class="w">
</span><span class="nf">c</span><span class="p">(</span><span
class="n">e1</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"S4_beer"</span><span
class="p">,</span><span class="w"> </span><span
class="n">e2</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"S4_opener"</span><span
class="p">),</span><span class="w">
          </span><span class="k">function</span><span class="p">
(</span><span class="n">e1</span><span class="p">,</span><span
class="w"> </span><span class="n">e2</span><span class="p">)
{</span><span class="w">
  </span><span class="k">if</span><span class="w"> </span><span
class="p">(</span><span class="n">inherits</span><span class="p">
(</span><span class="n">e2</span><span class="p">,</span><span
class="w"> </span><span class="s2">"S4_opener"</span><span class="p">))
</span><span class="w"> </span><span class="p">{</span><span class="w">
        </span><span class="nf">return</span><span class="p">
(</span><span class="n">.S4_opened_beer</span><span class="p">
(</span><span class="n">type</span><span class="w">  </span><span
class="o">=</span><span class="w"> </span><span
class="n">paste</span><span class="p">(</span><span class="s2">"opened"
</span><span class="p">,</span><span class="w"> </span><span
class="n">e1</span><span class="o">@</span><span
class="n">type</span><span class="p">)))</span><span class="w">
  </span><span class="p">}</span><span class="w"> </span><span
class="k">else</span><span class="w"> </span><span
class="k">if</span><span class="w"> </span><span class="p">
(</span><span class="n">inherits</span><span class="p">(</span><span
class="n">e2</span><span class="p">,</span><span class="w">
</span><span class="s2">"numeric"</span><span class="p">))</span><span
```

```
class="w"> </span><span class="p">{</span><span class="w">
    </span><span class="n">print</span><span class="p">(</span><span
class="s2">"It's magic! You've got a case of beers!"</span><span
class="p">)</span><span class="w">
    </span><span class="nf">return</span><span class="p">(</span><span
class="n">.S4_case_of_beers</span><span class="p">(</span><span
class="n">n_beers</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="m">1</span><span class="w">
</span><span class="o">+</span><span class="w"> </span><span
class="n">e2</span><span class="p">))</span><span class="w">
  </span><span class="p">}</span><span class="w"> </span><span
class="k">else</span><span class="w"> </span><span class="p">
{</span><span class="w">
    </span><span class="nf">return</span><span class="p">(</span><span
class="n">e1</span><span class="p">)</span><span class="w">
  </span><span class="p">}</span><span class="w">
</span><span class="p">})</span><span class="w">

</span><span class="n">setMethod</span><span class="p">(</span><span
class="s2">"+"</span><span class="p">,</span><span class="w">
</span><span class="nf">c</span><span class="p">(</span><span
class="n">e1</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"S4_opener"</span><span
class="p">,</span><span class="w"> </span><span
class="n">e2</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"S4_beer"</span><span
class="p">),</span><span class="w">
          </span><span class="k">function</span><span class="p">
(</span><span class="n">e1</span><span class="p">,</span><span
class="w"> </span><span class="n">e2</span><span class="p">)
</span><span class="w"> </span><span class="n">e2</span><span
class="w"> </span><span class="o">+</span><span class="w"> </span><span
class="n">e1</span><span class="p">)</span><span class="w">
</span>
```

Alternatively, we can define a method for `Arith` geneneric and check, what method is exactly called at the moment. I decided to use the second approach, because it's more similar to the way the double dispatch is implemented in the **vctrs** library.

```
<span class="n">.S4_fun</span><span class="w"> </span><span class="o">
<-</span><span class="w"> </span><span class="k">function</span><span
class="p">(</span><span class="n">e1</span><span class="p">,
</span><span class="w"> </span><span class="n">e2</span><span
class="p">){</span><span class="w">
  </span><span class="k">if</span><span class="w"> </span><span
class="p">(</span><span class="n">inherits</span><span class="p">
(</span><span class="n">e2</span><span class="p">,</span><span
class="w"> </span><span class="s2">"S4_opener"</span><span class="p">))
</span><span class="w"> </span><span class="p">{</span><span class="w">
        </span><span class="nf">return</span><span class="p">
(</span><span class="n">.S4_opened_beer</span><span class="p">
```

```
(</span><span class="n">type</span><span class="w">  </span><span
class="o">=</span><span class="w"> </span><span
class="n">paste</span><span class="p">(</span><span class="s2">"opened"
</span><span class="p">,</span><span class="w"> </span><span
class="n">e1</span><span class="o">@</span><span
class="n">type</span><span class="p">)))</span><span class="w">
  </span><span class="p">}</span><span class="w"> </span><span
class="k">else</span><span class="w"> </span><span
class="k">if</span><span class="w"> </span><span class="p">
(</span><span class="n">inherits</span><span class="p">(</span><span
class="n">e2</span><span class="p">,</span><span class="w">
</span><span class="s2">"numeric"</span><span class="p">))</span><span
class="w"> </span><span class="p">{</span><span class="w">
    </span><span class="n">print</span><span class="p">(</span><span
class="s2">"It's magic! You've got a case of beers!"</span><span
class="p">)</span><span class="w">
    </span><span class="nf">return</span><span class="p">(</span><span
class="n">.S4_case_of_beers</span><span class="p">(</span><span
class="n">n_beers</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="m">1</span><span class="w">
</span><span class="o">+</span><span class="w"> </span><span
class="n">e2</span><span class="p">))</span><span class="w">
  </span><span class="p">}</span><span class="w"> </span><span
class="k">else</span><span class="w"> </span><span class="p">
{</span><span class="w">
    </span><span class="nf">return</span><span class="p">(</span><span
class="n">e1</span><span class="p">)</span><span class="w">
  </span><span class="p">}</span><span class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">setMethod</span><span class="p">(</span><span
class="s2">"Arith"</span><span class="p">,</span><span class="w">
</span><span class="nf">c</span><span class="p">(</span><span
class="n">e1</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"S4_beer"</span><span
class="p">,</span><span class="w"> </span><span
class="n">e2</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"S4_opener"</span><span
class="p">),</span><span class="w">
          </span><span class="k">function</span><span class="p">
(</span><span class="n">e1</span><span class="p">,</span><span
class="w"> </span><span class="n">e2</span><span class="p">)
</span><span class="w">
          </span><span class="p">{</span><span class="w">
            </span><span class="n">op</span><span class="w">
</span><span class="o">=</span><span class="w"> </span><span
class="n">.Generic</span><span class="p">[[</span><span
class="m">1</span><span class="p">]]</span><span class="w">
            </span><span class="nf">switch</span><span class="p">
(</span><span class="n">op</span><span class="p">,</span><span
class="w">
                  </span><span class="n">`+`</span><span class="w">
```

```
</span><span class="o">=</span><span class="w"> </span><span
class="n">.S4_fun</span><span class="p">(</span><span
class="n">e1</span><span class="p">,</span><span class="w">
</span><span class="n">e2</span><span class="p">),</span><span
class="w">
                    </span><span class="n">stop</span><span class="p">
(</span><span class="s2">"undefined operation"</span><span class="p">)
</span><span class="w">
            </span><span class="p">)</span><span class="w">
</span><span class="p">})</span><span class="w">

</span><span class="n">setMethod</span><span class="p">(</span><span
class="s2">"Arith"</span><span class="p">,</span><span class="w">
</span><span class="nf">c</span><span class="p">(</span><span
class="n">e1</span><span class="o">=</span><span class="s2">"S4_opener"
</span><span class="p">,</span><span class="w"> </span><span
class="n">e2</span><span class="o">=</span><span class="s2">"S4_beer"
</span><span class="p">),</span><span class="w">
          </span><span class="k">function</span><span class="p">
(</span><span class="n">e1</span><span class="p">,</span><span
class="w"> </span><span class="n">e2</span><span class="p">)
</span><span class="w">
          </span><span class="p">{</span><span class="w">
            </span><span class="n">op</span><span class="w">
</span><span class="o">=</span><span class="w"> </span><span
class="n">.Generic</span><span class="p">[[</span><span
class="m">1</span><span class="p">]]</span><span class="w">
            </span><span class="nf">switch</span><span class="p">
(</span><span class="n">op</span><span class="p">,</span><span
class="w">
                   </span><span class="n">`+`</span><span class="w">
</span><span class="o">=</span><span class="w"> </span><span
class="n">e2</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="n">e1</span><span
class="p">,</span><span class="w">
                    </span><span class="n">stop</span><span class="p">
(</span><span class="s2">"undefined operation"</span><span class="p">)
</span><span class="w">
            </span><span class="p">)</span><span class="w">
</span><span class="p">})</span><span class="w">
</span>
```

Let’s create our class instances and do a piece of math.

```
<span class="n">S4_pilsner</span><span class="w"> </span><span
class="o"><-</span><span class="w"> </span><span
class="n">.S4_beer</span><span class="p">(</span><span
class="n">type</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"Pilsner"</span><span
class="p">)</span><span class="w">
</span><span class="n">S4_opener</span><span class="w"> </span><span
class="o"><-</span><span class="w"> </span><span
```

```
class="n">.S4_opener</span><span class="p">(</span><span
class="n">ID</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="m">1</span><span
class="p">)</span><span class="w">
</span>

<span class="n">S4_pilsner</span><span class="w"> </span><span
class="o">+</span><span class="w"> </span><span
class="n">S4_opener</span><span class="w">
</span>

## An object of class "S4_opened_beer"
## Slot "type":
## [1] "opened Pilsner"

<span class="n">S4_opener</span><span class="w"> </span><span
class="o">+</span><span class="w"> </span><span
class="n">S4_pilsner</span><span class="w">
</span>

## An object of class "S4_opened_beer"
## Slot "type":
## [1] "opened Pilsner"
```

Declared methods are clear, and, the most important: they work correctly.

## vctrs library: a tidyverse approach

**vctrs** is an interesting library,
thought as a remedy for a couple of R disadvantages. It delivers, among others, a custom double-dispatch system based on well-known S3 mechanism.

At the first step we declare class ‘constructors’.

```
<span class="n">library</span><span class="p">(</span><span
class="n">vctrs</span><span class="p">)</span><span class="w">

</span><span class="n">.vec_beer</span><span class="w"> </span><span
class="o"><-</span><span class="w"> </span><span
class="k">function</span><span class="p">(</span><span
class="n">type</span><span class="p">){</span><span class="w">
  </span><span class="n">new_vctr</span><span class="p">(</span><span
class="n">.data</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="nf">list</span><span
class="p">(</span><span class="n">type</span><span class="w">
</span><span class="o">=</span><span class="w"> </span><span
class="n">type</span><span class="p">),</span><span class="w">
</span><span class="n">class</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span class="s2">"vec_beer"
</span><span class="p">)</span><span class="w">
</span><span class="p">}</span><span class="w">
```

```
</span><span class="n">.vec_opened_beer</span><span class="w">
</span><span class="o"><-</span><span class="w"> </span><span
class="k">function</span><span class="p">(</span><span
class="n">type</span><span class="p">){</span><span class="w">
  </span><span class="n">new_vctr</span><span class="p">(</span><span
class="n">.data</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="nf">list</span><span
class="p">(</span><span class="n">type</span><span class="w">
</span><span class="o">=</span><span class="w"> </span><span
class="n">type</span><span class="p">),</span><span class="w">
</span><span class="n">class</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="s2">"vec_opened_beer"</span><span class="p">)</span><span
class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">.vec_case_of_beers</span><span class="w">
</span><span class="o"><-</span><span class="w"> </span><span
class="k">function</span><span class="p">(</span><span
class="n">n_beers</span><span class="p">){</span><span class="w">
  </span><span class="n">new_vctr</span><span class="p">(</span><span
class="n">.data</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="nf">list</span><span
class="p">(</span><span class="n">n_beers</span><span class="w">
</span><span class="o">=</span><span class="w"> </span><span
class="n">n_beers</span><span class="p">),</span><span class="w">
</span><span class="n">class</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="s2">"vec_case_of_beers"</span><span class="p">)</span><span
class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">.vec_opener</span><span class="w"> </span><span
class="o"><-</span><span class="w"> </span><span
class="k">function</span><span class="p">(){</span><span class="w">
  </span><span class="n">new_vctr</span><span class="p">(</span><span
class="n">.data</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="nf">list</span><span
class="p">(),</span><span class="w"> </span><span
class="n">class</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="s2">"vec_opener"</span>
<span class="p">)</span><span class="w">
</span><span class="p">}</span><span class="w">
</span>
```

Then, we create class instances.

```
<span class="n">vec_pilsner</span><span class="w">   </span><span
class="o"><-</span><span class="w"> </span><span
class="n">.vec_beer</span><span class="p">(</span><span
class="s2">"pilnser"</span><span class="p">)</span><span class="w">
</span><span class="n">vec_opener</span><span class="w"> </span><span
```

```
class="o"><-</span><span class="w"> </span><span
class="n">.vec_opener</span><span class="p">()</span><span class="w">
</span><span class="n">print</span><span class="p">(</span><span
class="nf">class</span><span class="p">(</span><span
class="n">vec_pilsner</span><span class="p">))</span><span class="w">
</span>
```

```
## [1] "vec_beer"   "vctrs_vctr"
```

```
<span class="n">print</span><span class="p">(</span><span
class="nf">class</span><span class="p">(</span><span
class="n">vec_opener</span><span class="p">))</span><span class="w">
</span>
```

```
## [1] "vec_opener" "vctrs_vctr"
```

At the end, we write a double-dispatched methods **in vctrs style**. As you can see,

```
<span class="n">.fun</span><span class="w"> </span><span class="o">
<-</span><span class="w"> </span><span class="k">function</span><span
class="p">(</span><span class="n">a</span><span class="p">,</span><span
class="w"> </span><span class="n">b</span><span class="p">)
{</span><span class="w">
  </span><span class="k">if</span><span class="w"> </span><span
class="p">(</span><span class="n">inherits</span><span class="p">
(</span><span class="n">b</span><span class="p">,</span><span
class="w"> </span><span class="s2">"vec_opener"</span><span
class="p">))</span><span class="w"> </span><span class="p">
{</span><span class="w">
        </span><span class="nf">return</span><span class="p">
(</span><span class="n">.vec_opened_beer</span><span class="p">
(</span><span class="n">type</span><span class="w">  </span><span
class="o">=</span><span class="w"> </span><span
class="n">paste</span><span class="p">(</span><span class="s2">"opened"
</span><span class="p">,</span><span class="w"> </span><span
class="n">a</span><span class="o">$</span><span
class="n">type</span><span class="p">)))</span><span class="w">
  </span><span class="p">}</span><span class="w"> </span><span
class="k">else</span><span class="w"> </span><span
class="k">if</span><span class="w"> </span><span class="p">
(</span><span class="n">inherits</span><span class="p">(</span><span
class="n">b</span><span class="p">,</span><span class="w"> </span><span
class="s2">"numeric"</span><span class="p">))</span><span class="w">
</span><span class="p">{</span><span class="w">
    </span><span class="n">print</span><span class="p">(</span><span
class="s2">"It's magic! You've got a case of beers!"</span><span
class="p">)</span><span class="w">
    </span><span class="nf">return</span><span class="p">(</span><span
class="n">.vec_case_of_beers</span><span class="p">(</span><span
class="n">n_beers</span><span class="w"> </span><span class="o">=
</span><span class="w"> </span><span class="m">1</span><span class="w">
</span><span class="o">+</span><span class="w"> </span><span
```

```
class="n">b</span><span class="p">))</span><span class="w">
  </span><span class="p">}</span><span class="w"> </span><span
class="k">else</span><span class="w"> </span><span class="p">
{</span><span class="w">
    </span><span class="nf">return</span><span class="p">(</span><span
class="n">a</span><span class="p">)</span><span class="w">
  </span><span class="p">}</span><span class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">vec_arith.vec_beer</span><span class="w">
</span><span class="o"><-</span><span class="w"> </span><span
class="k">function</span><span class="p">(</span><span
class="n">op</span><span class="p">,</span><span class="w">
</span><span class="n">x</span><span class="p">,</span><span class="w">
</span><span class="n">y</span><span class="p">,</span><span class="w">
</span><span class="n">...</span><span class="p">)</span><span
class="w"> </span><span class="p">{</span><span class="w">
  </span><span class="nf">UseMethod</span><span class="p">(</span><span
class="s2">"vec_arith.vec_beer"</span><span class="p">,</span><span
class="w"> </span><span class="n">y</span><span class="p">)</span><span
class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">vec_arith.vec_opener</span><span class="w">
</span><span class="o"><-</span><span class="w"> </span><span
class="k">function</span><span class="p">(</span><span
class="n">op</span><span class="p">,</span><span class="w">
</span><span class="n">x</span><span class="p">,</span><span class="w">
</span><span class="n">y</span><span class="p">,</span><span class="w">
</span><span class="n">...</span><span class="p">)</span><span
class="w"> </span><span class="p">{</span><span class="w">
  </span><span class="nf">UseMethod</span><span class="p">(</span><span
class="s2">"vec_arith.vec_opener"</span><span class="p">,</span><span
class="w"> </span><span class="n">y</span><span class="p">)</span><span
class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">vec_arith.vec_beer.vec_opener</span><span
class="w"> </span><span class="o"><-</span><span class="w">
</span><span class="k">function</span><span class="p">(</span><span
class="n">op</span><span class="p">,</span><span class="w">
</span><span class="n">x</span><span class="p">,</span><span class="w">
</span><span class="n">y</span><span class="p">,</span><span class="w">
</span><span class="n">...</span><span class="p">){</span><span
class="w">
  </span><span class="nf">switch</span><span class="p">(</span><span
class="n">op</span><span class="p">,</span><span class="w">
        </span><span class="n">`+`</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="n">.fun</span><span class="p">(</span><span
class="n">x</span><span class="p">,</span><span class="w"> </span><span
class="n">y</span><span class="p">),</span><span class="w">
```

```
        </span><span class="n">stop_incompatible_op</span><span
class="p">(</span><span class="n">op</span><span class="p">,
</span><span class="w"> </span><span class="n">x</span><span
class="p">,</span><span class="w"> </span><span class="n">y</span><span
class="p">)</span><span class="w">
  </span><span class="p">)</span><span class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">vec_arith.vec_opener.vec_beer</span><span
class="w"> </span><span class="o"><-</span><span class="w">
</span><span class="k">function</span><span class="p">(</span><span
class="n">op</span><span class="p">,</span><span class="w">
</span><span class="n">x</span><span class="p">,</span><span class="w">
</span><span class="n">y</span><span class="p">,</span><span class="w">
</span><span class="n">...</span><span class="p">){</span><span
class="w">
  </span><span class="n">y</span><span class="w"> </span><span
class="o">+</span><span class="w"> </span><span class="n">x</span><span
class="w">
</span><span class="p">}</span><span class="w">

</span><span class="n">vec_pilsner</span><span class="w"> </span><span
class="o">+</span><span class="w"> </span><span
class="n">vec_opener</span><span class="w">
</span>

## <vec_opened_beer[1]>
##           type
## opened pilnser

<span class="n">vec_opener</span><span class="w"> </span><span
class="o">+</span><span class="w"> </span><span
class="n">vec_pilsner</span><span class="w">
</span>

## <vec_opened_beer[1]>
##           type
## opened pilnser
```

It works properly, too.

# Benchmark

I’ve created all the classes and methods above not only to demonstate, how to implement double dispatch in R. My main goal is to benchmark both approaches and check, which one has smaller overhead. The hardware I used for the test looks as follows:

```
## $vendor_id
## [1] "GenuineIntel"
##
## $model_name
## [1] "Intel(R) Core(TM) i3 CPU       M 350  @ 2.27GHz"
```

```
##
## $no_of_cores
## [1] 4

## 8.19 GB

<span class="n">sessionInfo</span><span class="p">()</span><span
class="w">
</span>

## R version 3.6.1 (2019-07-05)
## Platform: x86_64-pc-linux-gnu (64-bit)
## Running under: Ubuntu 18.04.2 LTS
##
## Matrix products: default
## BLAS:   /usr/local/lib/R/lib/libRblas.so
## LAPACK: /usr/local/lib/R/lib/libRlapack.so
##
## locale:
##  [1] LC_CTYPE=pl_PL.UTF-8       LC_NUMERIC=C
##  [3] LC_TIME=pl_PL.UTF-8        LC_COLLATE=pl_PL.UTF-8
##  [5] LC_MONETARY=pl_PL.UTF-8    LC_MESSAGES=en_US.utf8
##  [7] LC_PAPER=pl_PL.UTF-8       LC_NAME=C
##  [9] LC_ADDRESS=C               LC_TELEPHONE=C
## [11] LC_MEASUREMENT=pl_PL.UTF-8 LC_IDENTIFICATION=C
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
## [1] vctrs_0.2.3
##
## loaded via a namespace (and not attached):
##  [1] Rcpp_1.0.3            benchmarkmeData_1.0.3 knitr_1.23
##  [4] magrittr_1.5          tidyselect_0.2.5      doParallel_1.0.15
##  [7] lattice_0.20-38       R6_2.4.0              rlang_0.4.2
## [10] foreach_1.4.7         httr_1.4.1            stringr_1.4.0
## [13] dplyr_0.8.3           tools_3.6.1           parallel_3.6.1
## [16] grid_3.6.1            xfun_0.9              htmltools_0.3.6
## [19] iterators_1.0.12      yaml_2.2.0            digest_0.6.25
## [22] assertthat_0.2.1      tibble_2.1.3          benchmarkme_1.0.3
## [25] crayon_1.3.4          Matrix_1.2-17         purrr_0.3.3
## [28] codetools_0.2-16      glue_1.3.1            evaluate_0.14
## [31] rmarkdown_1.14        stringi_1.4.3         pillar_1.4.2
## [34] compiler_3.6.1        pkgconfig_2.0.2
```

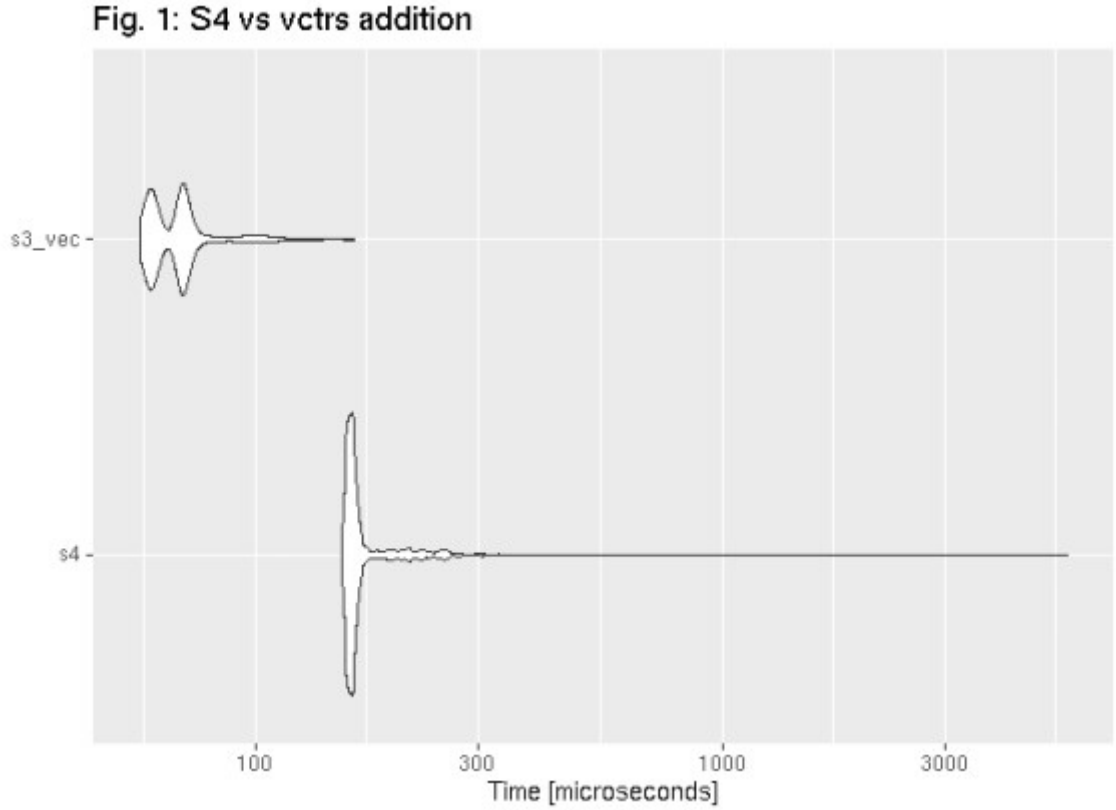
It's my good old notebook, which is not a beast.

```
<span class="n">library</span><span class="p">(</span><span
class="n">microbenchmark</span><span class="p">)</span><span class="w">
</span><span class="n">library</span><span class="p">(</span><span
class="n">ggplot2</span><span class="p">)</span><span class="w">
</span>
```

### Beer + opener

```
<span class="n">bm1</span><span class="w"> </span><span class="o">
<-</span><span class="w"> </span><span class="n">microbenchmark</
span><span class="p">(</span><span class="w">
  </span><span class="n">s4</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="n">S4_pilsner</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="n">S4_opener</span><span
class="p">,</span><span class="w">
  </span><span class="n">s3_vec</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="n">vec_pilsner</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="n">vec_opener</span><span
class="p">,</span><span class="w">
  </span><span class="n">times</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="m">1000</span><span class="w">
</span><span class="p">)</span><span class="w">
</span>
```

```
## Unit: microseconds
##    expr     min       lq      mean   median       uq      max neval
##      s4 153.292 158.2120 178.40541 161.4225 165.6375 5506.681  1000
##  s3_vec  56.686  60.1265  69.52364  68.9240  70.8830  163.278  1000
```

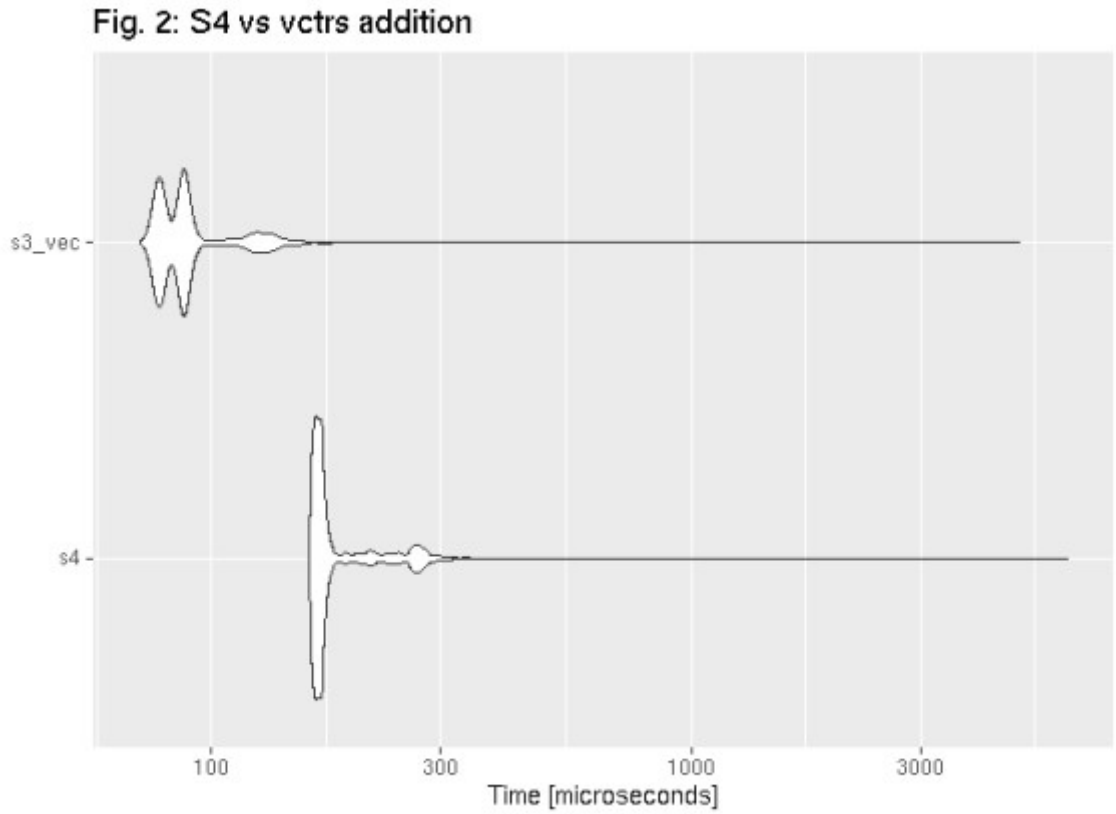



### Opener + beer

```
<span class="n">bm2</span><span class="w"> </span><span class="o">
```

```
<-</span><span class="w"> </span><span class="n">microbenchmark</
span><span class="p">(</span><span class="w">
  </span><span class="n">s4</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="n">S4_opener</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="n">S4_pilsner</span><span
class="p">,</span><span class="w">
  </span><span class="n">s3_vec</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="n">vec_opener</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="n">vec_pilsner</span><span
class="p">,</span><span class="w">
  </span><span class="n">times</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="m">1000</span><span class="w">
</span><span class="p">)</span><span class="w">
</span>
```

```
## Unit: microseconds
##    expr     min       lq      mean   median       uq      max neval
##      s4 159.512 164.6735 191.74781 168.9655 176.3165 6068.477  1000
##  s3_vec  71.110  78.5835  96.22535  86.6720  89.4015 4796.377  1000
```

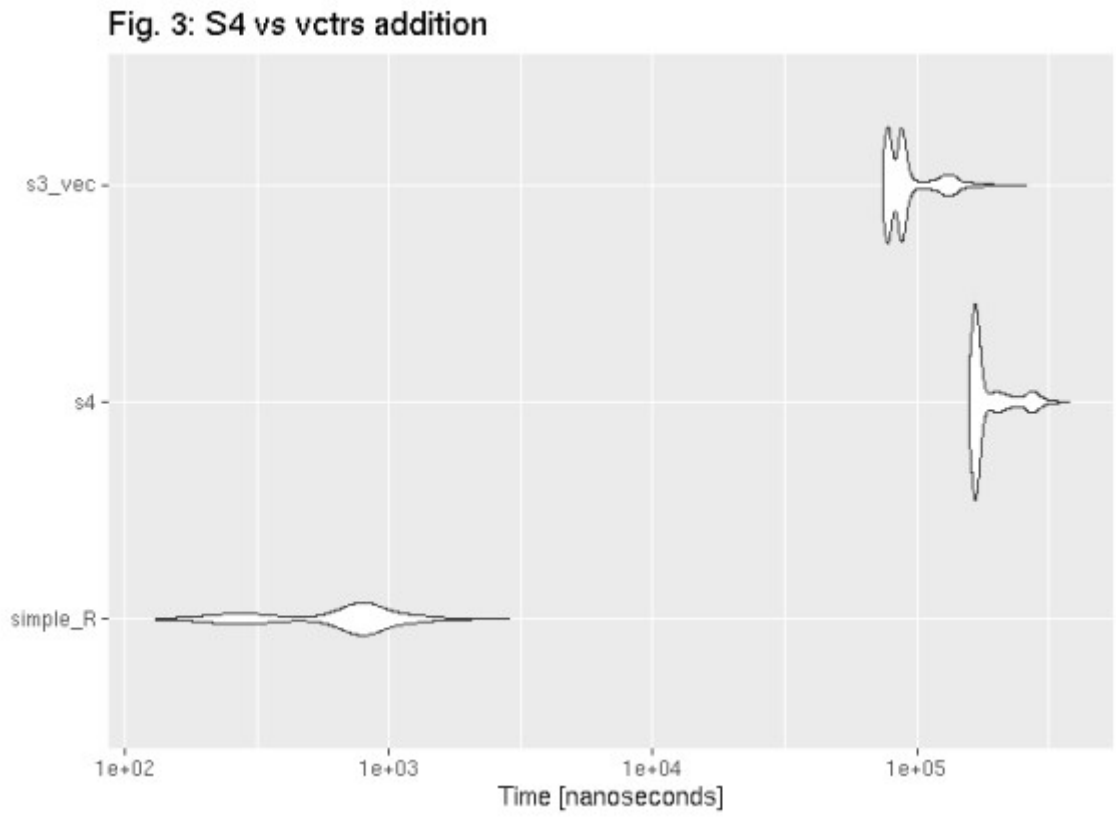



### Bonus: opener + beer vs addtion of numerics

```
<span class="n">bm3</span><span class="w"> </span><span class="o">
<-</span><span class="w"> </span><span class="n">microbenchmark</
span><span class="p">(</span><span class="w">
  </span><span class="n">simple_R</span><span class="w"> </span><span
```

```
class="o">=</span><span class="w"> </span><span class="m">1</span><span
class="w"> </span><span class="o">+</span><span class="w"> </span><span
class="m">2</span><span class="p">,</span><span class="w">
  </span><span class="n">s4</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="n">S4_opener</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="n">S4_pilsner</span><span
class="p">,</span><span class="w">
  </span><span class="n">s3_vec</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="n">vec_opener</span><span class="w"> </span><span class="o">+
</span><span class="w"> </span><span class="n">vec_pilsner</span><span
class="p">,</span><span class="w">
  </span><span class="n">times</span><span class="w"> </span><span
class="o">=</span><span class="w"> </span><span
class="m">1000</span><span class="w">
</span><span class="p">)</span><span class="w">
</span>
```

```
## Unit: nanoseconds
##      expr    min       lq      mean   median     uq    max neval
##  simple_R    130    344.0    697.49    744.5    857   2862  1000
##        s4 158769 164522.5 189297.35 169270.5 198120 375648  1000
##    s3_vec  74775  78395.5  94786.28  87192.5  94085 258129  1000
```




## Conclusions

It seems that **vctrs-based** performs better than traditional **S4 methods**. Obviously, I checked only one operation and probably some

edge cases may exists. However, I think that it shows us some direction, what execution time we can expect.