

Likelihood Calculation Times

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```
# read RData files
timeTable <- NULL
valueTable <- NULL

for(compiler in c("icpc-omp-for", "icpc-omp-simd", "icpc-omp-for-simd")) {
  for(tryNo in 1:10) {
    for(nCores in c(1, 2, 4, 6, 8, 10)) {
      dataFile <- paste0("Results_", compiler, "_", nCores, "_cores_", tryNo, ".RData")

      if(file.exists(dataFile)) {
        load(dataFile)
        if(is.null(values[["tryNo"]])) {
          values[, tryNo:=1]
        }
        if(is.null(times[["tryNo"]])) {
          times[, tryNo:=1]
        }
        valueTable <- rbind(valueTable, values)
        timeTable <- rbind(timeTable, times)
      }
    }
  }
}

setkey(timeTable, compilerInfo, cpuInfo, nCores, treeType, N, expr)

timeTable <- timeTable[expr != "gc"]

# average the times over the four trees for each N
# we remove the implementation "POUMM (C++/Arrays+SIMD)"
# since it only uses the default vectorization (not omp-simd)
timeTable <-
  timeTable[
    cpuInfo=="model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz",
    list(time_ms_per_try = mean(mean)),
    by=list(cpuInfo, nCores, compilerInfo, expr, N, tryNo)]

# pick the mins over the tries
timeTable <-
  timeTable[, list(time_ms = min(time_ms_per_try)),
    by=list(cpuInfo, nCores, compilerInfo, expr, N)]

# take best single-core time as reference for omp-for-simd
timeTable <- merge(
  timeTable,
  timeTable[expr == "POUMM: C++, omp" &
```

```

        compilerInfo == "icpc-omp-for-simd" & nCores == 1,
        list(ref_time_omp_for_simd = time_ms), keyby = N],
    by = "N")

#take best single-core time as reference for omp-for
timeTable <- merge(
    timeTable,
    timeTable[expr == "POUMM: C++, omp" &
        compilerInfo == "icpc-omp-for" & nCores == 1,
        list(ref_time_omp_for = time_ms), keyby = N],
    by = "N")

timeTable[, rel_speedup_omp_for_simd:=ref_time_omp_for_simd/time_ms]

##          N                                cpuInfo nCores
##  1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      1
##  2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
##  3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
##  4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
##  5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz     10
##      compilerInfo      expr      time_ms ref_time_omp_for_simd
##  1: icpc-omp-for POUMM: C++, omp 0.07081990      0.06998958
##  2: icpc-omp-for POUMM: C++, omp 0.08642710      0.06998958
##  3: icpc-omp-for POUMM: C++, omp 0.09145613      0.06998958
##  4: icpc-omp-for POUMM: C++, omp 0.09085248      0.06998958
##  5: icpc-omp-for POUMM: C++, omp 0.09362343      0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475      4.83427091
## 112: icpc-omp-simd POUMM: C++, omp 2.03031054      4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305      4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484      4.83427091
## 115: icpc-omp-simd POUMM: C++, omp 1.30249328      4.83427091
##      ref_time_omp_for rel_speedup_omp_for_simd
##  1:      0.0708199      0.9882756
##  2:      0.0708199      0.8098106
##  3:      0.0708199      0.7652803
##  4:      0.0708199      0.7703651
##  5:      0.0708199      0.7475648
## ---
## 111:      16.4633068      1.4045295
## 112:      16.4633068      2.3810500
## 113:      16.4633068      2.9179188
## 114:      16.4633068      3.3652071
## 115:      16.4633068      3.7115515

timeTable[, rel_speedup_omp_for:=ref_time_omp_for/time_ms]

##          N                                cpuInfo nCores

```

```

## 1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 1
## 2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 2
## 3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 4
## 4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 6
## 5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 10
## compilerInfo expr time_ms ref_time_omp_for_simd
## 1: icpc-omp-for POUMM: C++, omp 0.07081990 0.06998958
## 2: icpc-omp-for POUMM: C++, omp 0.08642710 0.06998958
## 3: icpc-omp-for POUMM: C++, omp 0.09145613 0.06998958
## 4: icpc-omp-for POUMM: C++, omp 0.09085248 0.06998958
## 5: icpc-omp-for POUMM: C++, omp 0.09362343 0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475 4.83427091
## 112: icpc-omp-simd POUMM: C++, omp 2.03031054 4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305 4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484 4.83427091
## 115: icpc-omp-simd POUMM: C++, omp 1.30249328 4.83427091
## ref_time_omp_for rel_speedup_omp_for_simd rel_speedup_omp_for
## 1: 0.0708199 0.9882756 1.0000000
## 2: 0.0708199 0.8098106 0.8194177
## 3: 0.0708199 0.7652803 0.7743592
## 4: 0.0708199 0.7703651 0.7795042
## 5: 0.0708199 0.7475648 0.7564335
## ---
## 111: 16.4633068 1.4045295 4.7831826
## 112: 16.4633068 2.3810500 8.1087629
## 113: 16.4633068 2.9179188 9.9370916
## 114: 16.4633068 3.3652071 11.4603501
## 115: 16.4633068 3.7115515 12.6398401

```

```
timeTable[, compiler:='Intel v16.0.0']
```

```

## N cpuInfo nCores
## 1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 1
## 2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 2
## 3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 4
## 4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 6
## 5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 10
## compilerInfo expr time_ms ref_time_omp_for_simd
## 1: icpc-omp-for POUMM: C++, omp 0.07081990 0.06998958
## 2: icpc-omp-for POUMM: C++, omp 0.08642710 0.06998958
## 3: icpc-omp-for POUMM: C++, omp 0.09145613 0.06998958
## 4: icpc-omp-for POUMM: C++, omp 0.09085248 0.06998958

```

```

## 5: icpc-omp-for POUMM: C++, omp 0.09362343 0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475 4.83427091
## 112: icpc-omp-simd POUMM: C++, omp 2.03031054 4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305 4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484 4.83427091
## 115: icpc-omp-simd POUMM: C++, omp 1.30249328 4.83427091
## ref_time_omp_for rel_speedup_omp_for simd rel_speedup_omp_for
## 1: 0.0708199 0.9882756 1.0000000
## 2: 0.0708199 0.8098106 0.8194177
## 3: 0.0708199 0.7652803 0.7743592
## 4: 0.0708199 0.7703651 0.7795042
## 5: 0.0708199 0.7475648 0.7564335
## ---
## 111: 16.4633068 1.4045295 4.7831826
## 112: 16.4633068 2.3810500 8.1087629
## 113: 16.4633068 2.9179188 9.9370916
## 114: 16.4633068 3.3652071 11.4603501
## 115: 16.4633068 3.7115515 12.6398401
## compiler
## 1: Intel v16.0.0
## 2: Intel v16.0.0
## 3: Intel v16.0.0
## 4: Intel v16.0.0
## 5: Intel v16.0.0
## ---
## 111: Intel v16.0.0
## 112: Intel v16.0.0
## 113: Intel v16.0.0
## 114: Intel v16.0.0
## 115: Intel v16.0.0

```

```

timeTable[, omp_for:= ((compilerInfo %in% c("icpc-omp-for", "icpc-omp-for-simd")) &
  expr == "POUMM: C++, omp")]

```

```

## N cpuInfo nCores
## 1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 1
## 2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 2
## 3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 4
## 4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 6
## 5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz 10
## compilerInfo expr time_ms ref_time_omp_for simd
## 1: icpc-omp-for POUMM: C++, omp 0.07081990 0.06998958
## 2: icpc-omp-for POUMM: C++, omp 0.08642710 0.06998958
## 3: icpc-omp-for POUMM: C++, omp 0.09145613 0.06998958
## 4: icpc-omp-for POUMM: C++, omp 0.09085248 0.06998958
## 5: icpc-omp-for POUMM: C++, omp 0.09362343 0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475 4.83427091

```

```

## 112: icpc-omp-simd POUMM: C++, omp 2.03031054      4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305      4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484      4.83427091
## 115: icpc-omp-simd POUMM: C++, omp 1.30249328      4.83427091
##      ref_time_omp_for rel_speedup_omp_for_simd rel_speedup_omp_for
## 1:      0.0708199      0.9882756      1.0000000
## 2:      0.0708199      0.8098106      0.8194177
## 3:      0.0708199      0.7652803      0.7743592
## 4:      0.0708199      0.7703651      0.7795042
## 5:      0.0708199      0.7475648      0.7564335
## ---
## 111:      16.4633068      1.4045295      4.7831826
## 112:      16.4633068      2.3810500      8.1087629
## 113:      16.4633068      2.9179188      9.9370916
## 114:      16.4633068      3.3652071     11.4603501
## 115:      16.4633068      3.7115515     12.6398401
##      compiler omp_for
## 1: Intel v16.0.0      TRUE
## 2: Intel v16.0.0      TRUE
## 3: Intel v16.0.0      TRUE
## 4: Intel v16.0.0      TRUE
## 5: Intel v16.0.0      TRUE
## ---
## 111: Intel v16.0.0      FALSE
## 112: Intel v16.0.0      FALSE
## 113: Intel v16.0.0      FALSE
## 114: Intel v16.0.0      FALSE
## 115: Intel v16.0.0      FALSE

```

```

timeTable[, omp_simd:= (compilerInfo != "icpc-omp-for" &
                        expr == "POUMM: C++, omp")]

```

```

##      N      cpuInfo nCores
## 1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      1
## 2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz     10
##      compilerInfo      expr      time_ms ref_time_omp_for_simd
## 1: icpc-omp-for POUMM: C++, omp 0.07081990      0.06998958
## 2: icpc-omp-for POUMM: C++, omp 0.08642710      0.06998958
## 3: icpc-omp-for POUMM: C++, omp 0.09145613      0.06998958
## 4: icpc-omp-for POUMM: C++, omp 0.09085248      0.06998958
## 5: icpc-omp-for POUMM: C++, omp 0.09362343      0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475      4.83427091
## 112: icpc-omp-simd POUMM: C++, omp 2.03031054      4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305      4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484      4.83427091

```

```

## 115: icpc-omp-simd POUMM: C++, omp 1.30249328      4.83427091
##      ref_time_omp_for rel_speedup_omp_for_simd rel_speedup_omp_for
## 1:      0.0708199      0.9882756      1.0000000
## 2:      0.0708199      0.8098106      0.8194177
## 3:      0.0708199      0.7652803      0.7743592
## 4:      0.0708199      0.7703651      0.7795042
## 5:      0.0708199      0.7475648      0.7564335
## ---
## 111:      16.4633068      1.4045295      4.7831826
## 112:      16.4633068      2.3810500      8.1087629
## 113:      16.4633068      2.9179188      9.9370916
## 114:      16.4633068      3.3652071     11.4603501
## 115:      16.4633068      3.7115515     12.6398401
##      compiler omp_for omp_simd
## 1: Intel v16.0.0      TRUE      FALSE
## 2: Intel v16.0.0      TRUE      FALSE
## 3: Intel v16.0.0      TRUE      FALSE
## 4: Intel v16.0.0      TRUE      FALSE
## 5: Intel v16.0.0      TRUE      FALSE
## ---
## 111: Intel v16.0.0      FALSE      TRUE
## 112: Intel v16.0.0      FALSE      TRUE
## 113: Intel v16.0.0      FALSE      TRUE
## 114: Intel v16.0.0      FALSE      TRUE
## 115: Intel v16.0.0      FALSE      TRUE

```

```
timeTable[, Implementation:=expr]
```

```

##      N      cpuInfo nCores
## 1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      1
## 2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz     10
##      compilerInfo      expr      time_ms ref_time_omp_for_simd
## 1: icpc-omp-for POUMM: C++, omp 0.07081990      0.06998958
## 2: icpc-omp-for POUMM: C++, omp 0.08642710      0.06998958
## 3: icpc-omp-for POUMM: C++, omp 0.09145613      0.06998958
## 4: icpc-omp-for POUMM: C++, omp 0.09085248      0.06998958
## 5: icpc-omp-for POUMM: C++, omp 0.09362343      0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475      4.83427091
## 112: icpc-omp-simd POUMM: C++, omp 2.03031054      4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305      4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484      4.83427091
## 115: icpc-omp-simd POUMM: C++, omp 1.30249328      4.83427091
##      ref_time_omp_for rel_speedup_omp_for_simd rel_speedup_omp_for
## 1:      0.0708199      0.9882756      1.0000000
## 2:      0.0708199      0.8098106      0.8194177

```

```

## 3:      0.0708199      0.7652803      0.7743592
## 4:      0.0708199      0.7703651      0.7795042
## 5:      0.0708199      0.7475648      0.7564335
## ---
## 111:    16.4633068      1.4045295      4.7831826
## 112:    16.4633068      2.3810500      8.1087629
## 113:    16.4633068      2.9179188      9.9370916
## 114:    16.4633068      3.3652071     11.4603501
## 115:    16.4633068      3.7115515     12.6398401
##      compiler omp_for omp_simd Implementation
## 1: Intel v16.0.0  TRUE  FALSE POUMM: C++, omp
## 2: Intel v16.0.0  TRUE  FALSE POUMM: C++, omp
## 3: Intel v16.0.0  TRUE  FALSE POUMM: C++, omp
## 4: Intel v16.0.0  TRUE  FALSE POUMM: C++, omp
## 5: Intel v16.0.0  TRUE  FALSE POUMM: C++, omp
## ---
## 111: Intel v16.0.0  FALSE  TRUE POUMM: C++, omp
## 112: Intel v16.0.0  FALSE  TRUE POUMM: C++, omp
## 113: Intel v16.0.0  FALSE  TRUE POUMM: C++, omp
## 114: Intel v16.0.0  FALSE  TRUE POUMM: C++, omp
## 115: Intel v16.0.0  FALSE  TRUE POUMM: C++, omp

```

```

timeTable[compilerInfo == "icpc-omp-simd" & expr == "POUMM: C++, omp",
  Implementation := paste0(Implementation, "-simd")]

```

```

##      N      cpuInfo nCores
## 1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      1
## 2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz     10
##      compilerInfo      expr      time_ms ref_time_omp_for_simd
## 1: icpc-omp-for POUMM: C++, omp 0.07081990      0.06998958
## 2: icpc-omp-for POUMM: C++, omp 0.08642710      0.06998958
## 3: icpc-omp-for POUMM: C++, omp 0.09145613      0.06998958
## 4: icpc-omp-for POUMM: C++, omp 0.09085248      0.06998958
## 5: icpc-omp-for POUMM: C++, omp 0.09362343      0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475      4.83427091
## 112: icpc-omp-simd POUMM: C++, omp 2.03031054      4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305      4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484      4.83427091
## 115: icpc-omp-simd POUMM: C++, omp 1.30249328      4.83427091
##      ref_time_omp_for rel_speedup_omp_for_simd rel_speedup_omp_for
## 1:      0.0708199      0.9882756      1.0000000
## 2:      0.0708199      0.8098106      0.8194177
## 3:      0.0708199      0.7652803      0.7743592
## 4:      0.0708199      0.7703651      0.7795042
## 5:      0.0708199      0.7475648      0.7564335

```



```

## ---
## 111:      16.4633068      1.4045295      4.7831826
## 112:      16.4633068      2.3810500      8.1087629
## 113:      16.4633068      2.9179188      9.9370916
## 114:      16.4633068      3.3652071     11.4603501
## 115:      16.4633068      3.7115515     12.6398401
##      compiler omp_for omp_simd      Implementation
## 1: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp
## 2: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp
## 3: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp
## 4: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp
## 5: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp
## ---
## 111: Intel v16.0.0      FALSE      TRUE POUMM: C++, omp-simd
## 112: Intel v16.0.0      FALSE      TRUE POUMM: C++, omp-simd
## 113: Intel v16.0.0      FALSE      TRUE POUMM: C++, omp-simd
## 114: Intel v16.0.0      FALSE      TRUE POUMM: C++, omp-simd
## 115: Intel v16.0.0      FALSE      TRUE POUMM: C++, omp-simd

timeTable[compilerInfo == "icpc-omp-for" & expr == "POUMM: C++, omp",
  Implementation := paste0(Implementation, "-for")]

##      N      cpuInfo nCores
## 1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      1
## 2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz     10
##      compilerInfo      expr      time_ms ref_time_omp_for_simd
## 1: icpc-omp-for POUMM: C++, omp 0.07081990      0.06998958
## 2: icpc-omp-for POUMM: C++, omp 0.08642710      0.06998958
## 3: icpc-omp-for POUMM: C++, omp 0.09145613      0.06998958
## 4: icpc-omp-for POUMM: C++, omp 0.09085248      0.06998958
## 5: icpc-omp-for POUMM: C++, omp 0.09362343      0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475      4.83427091
## 112: icpc-omp-simd POUMM: C++, omp 2.03031054      4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305      4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484      4.83427091
## 115: icpc-omp-simd POUMM: C++, omp 1.30249328      4.83427091
##      ref_time_omp_for rel_speedup_omp_for_simd rel_speedup_omp_for
## 1:      0.0708199      0.9882756      1.0000000
## 2:      0.0708199      0.8098106      0.8194177
## 3:      0.0708199      0.7652803      0.7743592
## 4:      0.0708199      0.7703651      0.7795042
## 5:      0.0708199      0.7475648      0.7564335
## ---
## 111:      16.4633068      1.4045295      4.7831826
## 112:      16.4633068      2.3810500      8.1087629

```



```

## 113:      16.4633068      2.9179188      9.9370916
## 114:      16.4633068      3.3652071     11.4603501
## 115:      16.4633068      3.7115515     12.6398401
##      compiler omp_for omp_simd      Implementation
## 1: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp-for
## 2: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp-for
## 3: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp-for
## 4: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp-for
## 5: Intel v16.0.0      TRUE      FALSE      POUMM: C++, omp-for
## ---
## 111: Intel v16.0.0      FALSE      TRUE      POUMM: C++, omp-simd
## 112: Intel v16.0.0      FALSE      TRUE      POUMM: C++, omp-simd
## 113: Intel v16.0.0      FALSE      TRUE      POUMM: C++, omp-simd
## 114: Intel v16.0.0      FALSE      TRUE      POUMM: C++, omp-simd
## 115: Intel v16.0.0      FALSE      TRUE      POUMM: C++, omp-simd

```

```

timeTable[compilerInfo == "icpc-omp-for-simd" & expr == "POUMM: C++, omp",
  Implementation := paste0(Implementation, "-for-simd")]

```

```

##      N      cpuInfo nCores
## 1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      1
## 2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz     10
##      compilerInfo      expr      time_ms ref_time_omp_for_simd
## 1: icpc-omp-for POUMM: C++, omp 0.07081990      0.06998958
## 2: icpc-omp-for POUMM: C++, omp 0.08642710      0.06998958
## 3: icpc-omp-for POUMM: C++, omp 0.09145613      0.06998958
## 4: icpc-omp-for POUMM: C++, omp 0.09085248      0.06998958
## 5: icpc-omp-for POUMM: C++, omp 0.09362343      0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475      4.83427091
## 112: icpc-omp-simd POUMM: C++, omp 2.03031054      4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305      4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484      4.83427091
## 115: icpc-omp-simd POUMM: C++, omp 1.30249328      4.83427091
##      ref_time_omp_for rel_speedup_omp_for_simd rel_speedup_omp_for
## 1:      0.0708199      0.9882756      1.0000000
## 2:      0.0708199      0.8098106      0.8194177
## 3:      0.0708199      0.7652803      0.7743592
## 4:      0.0708199      0.7703651      0.7795042
## 5:      0.0708199      0.7475648      0.7564335
## ---
## 111:      16.4633068      1.4045295      4.7831826
## 112:      16.4633068      2.3810500      8.1087629
## 113:      16.4633068      2.9179188      9.9370916
## 114:      16.4633068      3.3652071     11.4603501
## 115:      16.4633068      3.7115515     12.6398401

```

```
##          compiler omp_for omp_simd          Implementation
## 1: Intel v16.0.0    TRUE    FALSE  POUMM: C++, omp-for
## 2: Intel v16.0.0    TRUE    FALSE  POUMM: C++, omp-for
## 3: Intel v16.0.0    TRUE    FALSE  POUMM: C++, omp-for
## 4: Intel v16.0.0    TRUE    FALSE  POUMM: C++, omp-for
## 5: Intel v16.0.0    TRUE    FALSE  POUMM: C++, omp-for
## ---
## 111: Intel v16.0.0  FALSE    TRUE  POUMM: C++, omp-simd
## 112: Intel v16.0.0  FALSE    TRUE  POUMM: C++, omp-simd
## 113: Intel v16.0.0  FALSE    TRUE  POUMM: C++, omp-simd
## 114: Intel v16.0.0  FALSE    TRUE  POUMM: C++, omp-simd
## 115: Intel v16.0.0  FALSE    TRUE  POUMM: C++, omp-simd
```

```
timeTable[, Implementation :=
  paste0(Implementation, ' on ',
    nCores, ifelse(nCores == 1, " core", " cores"))]
```

```
##          N                                cpuInfo nCores
## 1: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      1
## 2: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 3: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 4: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 5: 1e+01 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## ---
## 111: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      2
## 112: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      4
## 113: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      6
## 114: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz      8
## 115: 1e+05 model name\t: Intel(R) Xeon(R) CPU E5-2697 v2 @ 2.70GHz     10
##          compilerInfo          expr    time_ms ref_time_omp_for_simd
## 1: icpc-omp-for POUMM: C++, omp 0.07081990      0.06998958
## 2: icpc-omp-for POUMM: C++, omp 0.08642710      0.06998958
## 3: icpc-omp-for POUMM: C++, omp 0.09145613      0.06998958
## 4: icpc-omp-for POUMM: C++, omp 0.09085248      0.06998958
## 5: icpc-omp-for POUMM: C++, omp 0.09362343      0.06998958
## ---
## 111: icpc-omp-simd POUMM: C++, omp 3.44191475      4.83427091
## 112: icpc-omp-simd POUMM: C++, omp 2.03031054      4.83427091
## 113: icpc-omp-simd POUMM: C++, omp 1.65675305      4.83427091
## 114: icpc-omp-simd POUMM: C++, omp 1.43654484      4.83427091
## 115: icpc-omp-simd POUMM: C++, omp 1.30249328      4.83427091
##          ref_time_omp_for rel_speedup_omp_for_simd rel_speedup_omp_for
## 1:          0.0708199          0.9882756          1.0000000
## 2:          0.0708199          0.8098106          0.8194177
## 3:          0.0708199          0.7652803          0.7743592
## 4:          0.0708199          0.7703651          0.7795042
## 5:          0.0708199          0.7475648          0.7564335
## ---
## 111:          16.4633068          1.4045295          4.7831826
## 112:          16.4633068          2.3810500          8.1087629
## 113:          16.4633068          2.9179188          9.9370916
## 114:          16.4633068          3.3652071         11.4603501
## 115:          16.4633068          3.7115515         12.6398401
##          compiler omp_for omp_simd          Implementation
## 1: Intel v16.0.0    TRUE    FALSE  POUMM: C++, omp-for on 1 core
```

```
## 2: Intel v16.0.0 TRUE FALSE POUMM: C++, omp-for on 2 cores
## 3: Intel v16.0.0 TRUE FALSE POUMM: C++, omp-for on 4 cores
## 4: Intel v16.0.0 TRUE FALSE POUMM: C++, omp-for on 6 cores
## 5: Intel v16.0.0 TRUE FALSE POUMM: C++, omp-for on 8 cores
## ---
## 111: Intel v16.0.0 FALSE TRUE POUMM: C++, omp-simd on 2 cores
## 112: Intel v16.0.0 FALSE TRUE POUMM: C++, omp-simd on 4 cores
## 113: Intel v16.0.0 FALSE TRUE POUMM: C++, omp-simd on 6 cores
## 114: Intel v16.0.0 FALSE TRUE POUMM: C++, omp-simd on 8 cores
## 115: Intel v16.0.0 FALSE TRUE POUMM: C++, omp-simd on 10 cores
```

```
timeTable <- timeTable[N %in% 10^(5:2)]
```

```
data <- timeTable[
  (nCores == 1 & omp_for & omp_simd) |
  (nCores == 1 & !omp_simd) |
  (nCores == 10 & omp_for),
  list(nCores, omp_for, omp_simd, time_ms,
       ref_time_omp_for_simd, ref_time_omp_for,
       rel_speedup_omp_for_simd, rel_speedup_omp_for),
  by=list(N, Implementation)]
```

```
data[, Implementation:=
  factor(Implementation,
    levels=c("diversitree: R on 1 core",
             "POUMM: R on 1 core",
             "geiger: C++ on 1 core",
             "diversitree: C++ on 1 core",
             "POUMM: C++, Armadillo on 1 core",
             "POUMM: C++, omp-for on 1 core",
             "POUMM: C++, omp-for on 10 cores",
             # "POUMM: C++, omp-simd on 1 core",
             "POUMM: C++, omp-for-simd on 1 core",
             "POUMM: C++, omp-for-simd on 10 cores"
            ), ordered = TRUE)]
```

##	N	Implementation	nCores	omp_for	omp_simd
## 1:	1e+02	POUMM: C++, omp-for on 1 core	1	TRUE	FALSE
## 2:	1e+02	POUMM: C++, omp-for on 10 cores	10	TRUE	FALSE
## 3:	1e+02	POUMM: C++, omp-for-simd on 1 core	1	TRUE	TRUE
## 4:	1e+02	geiger: C++ on 1 core	1	FALSE	FALSE
## 5:	1e+02	diversitree: R on 1 core	1	FALSE	FALSE
## 6:	1e+02	diversitree: C++ on 1 core	1	FALSE	FALSE
## 7:	1e+02	POUMM: R on 1 core	1	FALSE	FALSE
## 8:	1e+02	POUMM: C++, Armadillo on 1 core	1	FALSE	FALSE
## 9:	1e+02	POUMM: C++, omp-for-simd on 10 cores	10	TRUE	TRUE
## 10:	1e+03	POUMM: C++, omp-for on 1 core	1	TRUE	FALSE
## 11:	1e+03	POUMM: C++, omp-for on 10 cores	10	TRUE	FALSE
## 12:	1e+03	POUMM: C++, omp-for-simd on 1 core	1	TRUE	TRUE
## 13:	1e+03	geiger: C++ on 1 core	1	FALSE	FALSE
## 14:	1e+03	diversitree: R on 1 core	1	FALSE	FALSE
## 15:	1e+03	diversitree: C++ on 1 core	1	FALSE	FALSE
## 16:	1e+03	POUMM: R on 1 core	1	FALSE	FALSE
## 17:	1e+03	POUMM: C++, Armadillo on 1 core	1	FALSE	FALSE
## 18:	1e+03	POUMM: C++, omp-for-simd on 10 cores	10	TRUE	TRUE

## 19:	1e+04	POUMM: C++, omp-for on 1 core	1	TRUE	FALSE
## 20:	1e+04	POUMM: C++, omp-for on 10 cores	10	TRUE	FALSE
## 21:	1e+04	POUMM: C++, omp-for-simd on 1 core	1	TRUE	TRUE
## 22:	1e+04	geiger: C++ on 1 core	1	FALSE	FALSE
## 23:	1e+04	diversitree: R on 1 core	1	FALSE	FALSE
## 24:	1e+04	diversitree: C++ on 1 core	1	FALSE	FALSE
## 25:	1e+04	POUMM: R on 1 core	1	FALSE	FALSE
## 26:	1e+04	POUMM: C++, Armadillo on 1 core	1	FALSE	FALSE
## 27:	1e+04	POUMM: C++, omp-for-simd on 10 cores	10	TRUE	TRUE
## 28:	1e+05	POUMM: C++, omp-for on 1 core	1	TRUE	FALSE
## 29:	1e+05	POUMM: C++, omp-for on 10 cores	10	TRUE	FALSE
## 30:	1e+05	POUMM: C++, omp-for-simd on 1 core	1	TRUE	TRUE
## 31:	1e+05	geiger: C++ on 1 core	1	FALSE	FALSE
## 32:	1e+05	diversitree: R on 1 core	1	FALSE	FALSE
## 33:	1e+05	diversitree: C++ on 1 core	1	FALSE	FALSE
## 34:	1e+05	POUMM: R on 1 core	1	FALSE	FALSE
## 35:	1e+05	POUMM: C++, Armadillo on 1 core	1	FALSE	FALSE
## 36:	1e+05	POUMM: C++, omp-for-simd on 10 cores	10	TRUE	TRUE
##	N	Implementation	nCores	omp_for	omp_simd
##	time_ms	ref_time_omp_for_simd	ref_time_omp_for		
## 1:	8.548589e-02	0.07159467	0.08548589		
## 2:	1.099901e-01	0.07159467	0.08548589		
## 3:	7.159467e-02	0.07159467	0.08548589		
## 4:	2.395620e-01	0.07159467	0.08548589		
## 5:	1.440785e+00	0.07159467	0.08548589		
## 6:	5.447260e-02	0.07159467	0.08548589		
## 7:	3.916430e-01	0.07159467	0.08548589		
## 8:	1.011630e-01	0.07159467	0.08548589		
## 9:	1.066965e-01	0.07159467	0.08548589		
## 10:	2.421901e-01	0.12105158	0.24219009		
## 11:	1.763175e-01	0.12105158	0.24219009		
## 12:	1.210516e-01	0.12105158	0.24219009		
## 13:	5.987306e-01	0.12105158	0.24219009		
## 14:	1.549550e+01	0.12105158	0.24219009		
## 15:	2.298427e-01	0.12105158	0.24219009		
## 16:	1.330380e+00	0.12105158	0.24219009		
## 17:	2.724649e-01	0.12105158	0.24219009		
## 18:	1.595366e-01	0.12105158	0.24219009		
## 19:	1.728795e+00	0.54486412	1.72879507		
## 20:	4.373626e-01	0.54486412	1.72879507		
## 21:	5.448641e-01	0.54486412	1.72879507		
## 22:	4.244820e+00	0.54486412	1.72879507		
## 23:	1.516994e+02	0.54486412	1.72879507		
## 24:	2.351556e+00	0.54486412	1.72879507		
## 25:	8.132336e+00	0.54486412	1.72879507		
## 26:	1.742546e+00	0.54486412	1.72879507		
## 27:	3.026856e-01	0.54486412	1.72879507		
## 28:	1.646331e+01	4.83427091	16.46330680		
## 29:	2.578108e+00	4.83427091	16.46330680		
## 30:	4.834271e+00	4.83427091	16.46330680		
## 31:	4.940171e+01	4.83427091	16.46330680		
## 32:	1.604160e+03	4.83427091	16.46330680		
## 33:	2.659802e+01	4.83427091	16.46330680		
## 34:	8.801232e+01	4.83427091	16.46330680		

```
## 35: 1.597835e+01      4.83427091      16.46330680
## 36: 1.292233e+00      4.83427091      16.46330680
##      time_ms ref_time_omp_for_simd ref_time_omp_for
##      rel_speedup_omp_for_simd rel_speedup_omp_for
## 1:      0.837502828      1.00000000
## 2:      0.650919271      0.77721442
## 3:      1.000000000      1.19402582
## 4:      0.298856583      0.35684248
## 5:      0.049691437      0.05933286
## 6:      1.314324556      1.56933745
## 7:      0.182805932      0.21827500
## 8:      0.707716198      0.84503141
## 9:      0.671012507      0.80120626
## 10:      0.499820528      1.00000000
## 11:      0.686554705      1.37360246
## 12:      1.000000000      2.00071814
## 13:      0.202180396      0.40450599
## 14:      0.007812048      0.01562971
## 15:      0.526671472      1.05372117
## 16:      0.090990223      0.18204579
## 17:      0.444283274      0.88888561
## 18:      0.758769796      1.51808450
## 19:      0.315169874      1.00000000
## 20:      1.245794915      3.95277283
## 21:      1.000000000      3.17289209
## 22:      0.128359777      0.40727172
## 23:      0.003591735      0.01139619
## 24:      0.231703698      0.73517083
## 25:      0.066999705      0.21258283
## 26:      0.312682829      0.99210887
## 27:      1.800099529      5.71152155
## 28:      0.293639119      1.00000000
## 29:      1.875123548      6.38580974
## 30:      1.000000000      3.40554079
## 31:      0.097856354      0.33325381
## 32:      0.003013584      0.01026288
## 33:      0.181753047      0.61896742
## 34:      0.054927206      0.18705684
## 35:      0.302551358      1.03035099
## 36:      3.741020364      12.74019746
##      rel_speedup_omp_for_simd rel_speedup_omp_for
```

```
fill_colors <-
  c("#999999", "#0072B2", "#F0E442", "#E69F00", "#D55E00",
    "#56B4E9", "#56B4E9",
    "#009E73", "#009E73", "#009E73", "#009E73", "#009E73", "#009E73", "#009E73")

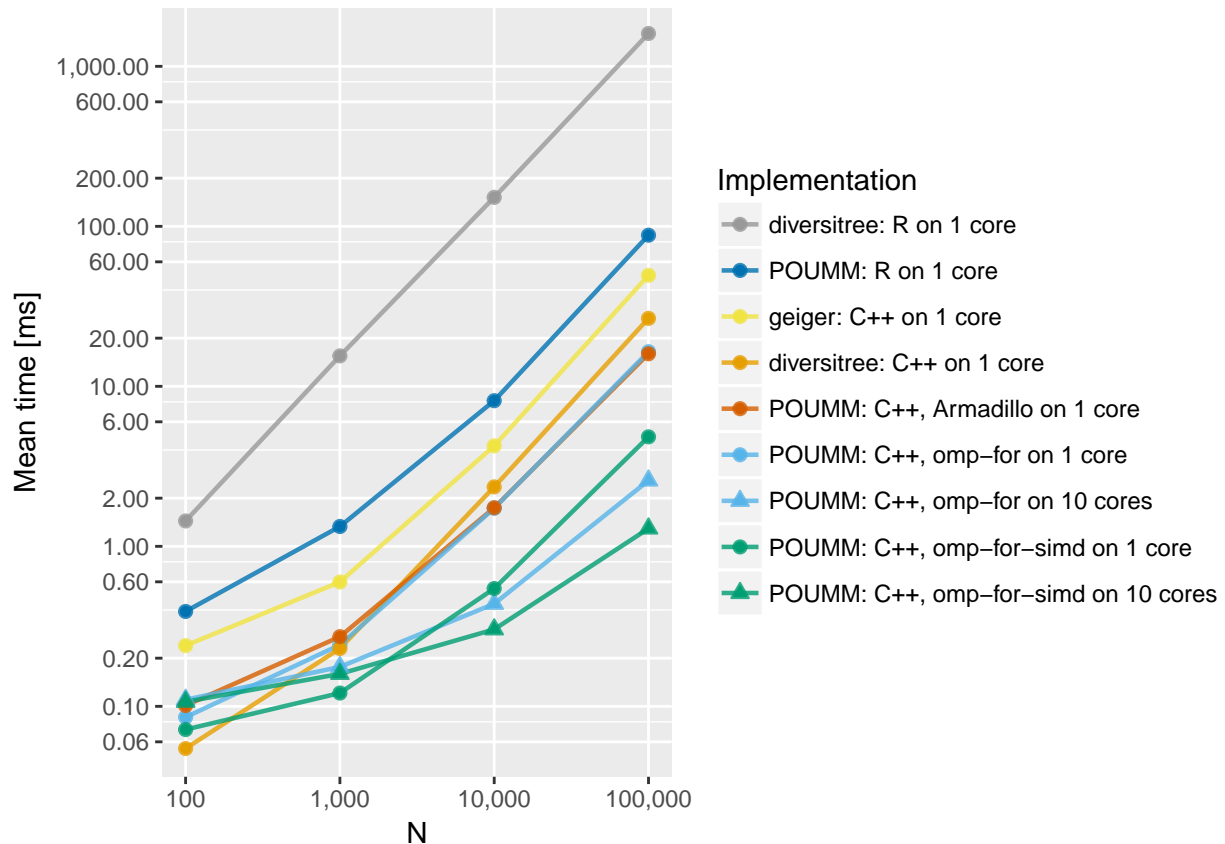
colors <- grDevices::adjustcolor(fill_colors, alpha.f=0.8)
shapes <- c(21, 21, 21, 21, 21,
           21, 24, 21, 24, 22, 25, 23, 23, 23)
names(colors) <- names(shapes) <- data[, levels(Implementation)]

ggplot(data[nCores %in% c(1, 10)]) +
  geom_line(aes(x = N, y = time_ms, col = Implementation), size=.8) +
```

```

geom_point(aes(x = N, y = time_ms, shape = Implementation,
               col = Implementation, fill = Implementation), size = 2) +
coord_cartesian(xlim = c(102, 105), ylim = c(0.06, 1400)) +
scale_y_continuous(trans=log10_trans(),
                   breaks = c(.06, 0.1,
                               seq(0.2, 1, by=.4),
                               seq(2, 10, by=4),
                               seq(20, 100, by=40),
                               seq(200, 1000, by=400)),
                   minor_breaks = c(.08,
                                     seq(0.4, 1, by=.4),
                                     seq(4, 10, by=4),
                                     seq(40, 100, by=40),
                                     seq(400, 1000, by=400)),
                   labels = comma) +
scale_x_continuous(trans=log10_trans(),
                   breaks = 10^(2:5),
                   minor_breaks = NULL,
                   labels = comma) +
scale_color_manual(values = colors) +
scale_fill_manual(values = fill_colors) +
scale_shape_manual(values = shapes) +
ylab("Mean time [ms]")

```



```

fill_colors <- c("#009E73", "#0072B2", "#D55E00", "#56B4E9")
colors <- grDevices::adjustcolor(fill_colors, alpha.f=0.8)

```

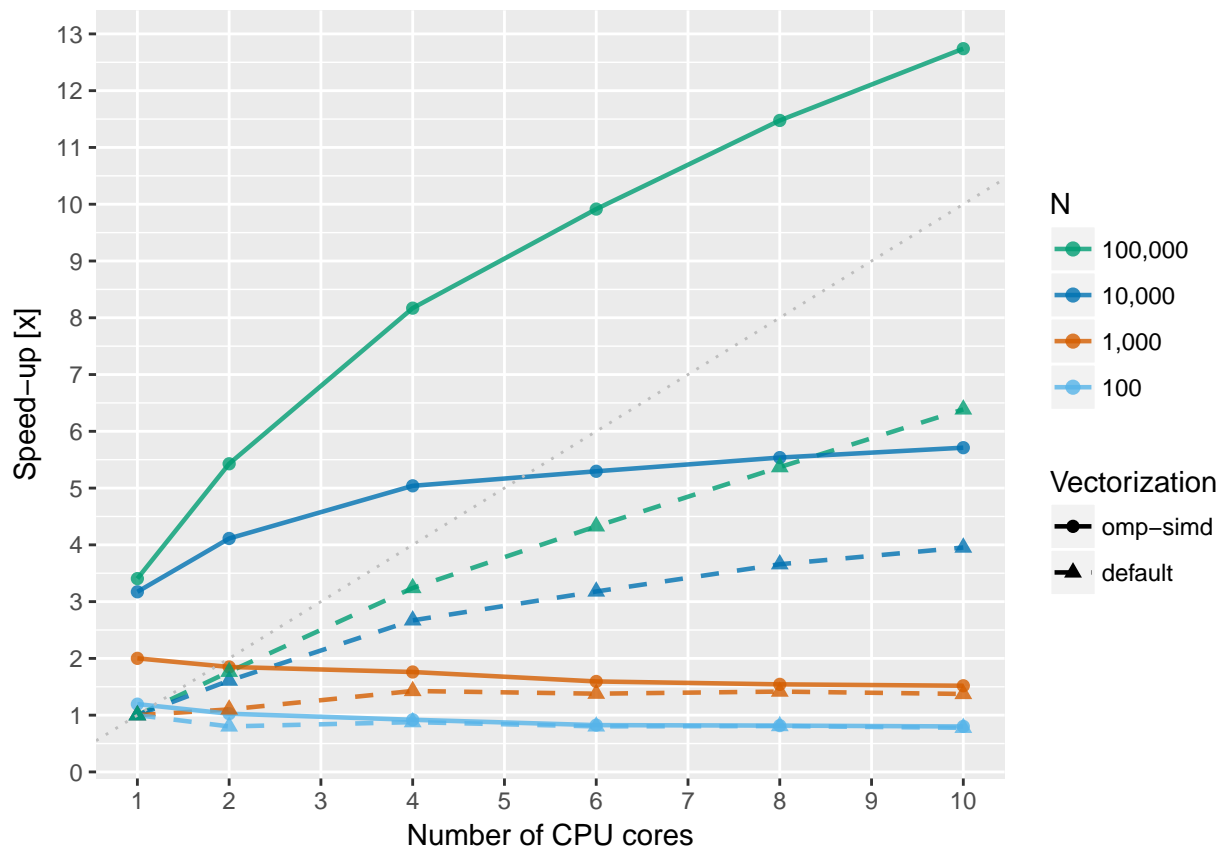
```

names(colors) <- names(fill_colors) <- c("100,000", "10,000", "1,000", "100")

ggplot(
  timeTable[
    (nCores %in% c(1, 2, 4, 6, 8, 10) & omp_for),
    list(Implementation,
        N = factor(as.integer(N),
                    levels=as.integer(10^(5:2)),
                    labels=c("100,000", "10,000", "1,000", "100")),
        time_ms, ref_time_omp_for, nCores,
        Vectorization = factor(omp_simd, levels = c(TRUE, FALSE),
                               labels = c("omp-simd", "default")))] +

  geom_line(
    aes(x=nCores, y = ref_time_omp_for / time_ms, col=N, linetype = Vectorization),
    size = 0.8) +
  geom_point(
    aes(x = nCores, y = ref_time_omp_for/time_ms,
        col = N, fill = N, shape = Vectorization), size = 2) +
  geom_abline(slope = 1, intercept = 0, col="grey", linetype=3) +
  scale_x_continuous(breaks = 1:12, minor_breaks = NULL, limits = c(1,10)) +
  scale_y_continuous(breaks = seq(0, 14, by=1), limits = c(0.5,12.8)) +
  scale_fill_manual(values = fill_colors) +
  scale_color_manual(values = colors) +
  scale_linetype_manual(values = c(1, 2)) +
  xlab("Number of CPU cores") + ylab("Speed-up [x]")

```




```

fill_colors <- c("#009E73", "#0072B2", "#D55E00", "#56B4E9")

colors <- grDevices::adjustcolor(fill_colors, alpha.f=0.8)

names(colors) <- names(fill_colors) <- c("100,000", "10,000", "1,000", "100")

ggplot(timeTable[(nCores %in% c(2, 4, 6, 8, 10) & omp_for & !omp_simd) |
  (Implementation == "POUMM: C++, omp-for on 1 core")],
  list(Implementation,
    N = factor(as.integer(N),
      levels=as.integer(10^(5:2)),
      labels=c("100,000", "10,000", "1,000", "100")),
    rel_speedup_omp_for, nCores])) +
  geom_line(aes(x=nCores, y=rel_speedup_omp_for, col=N), size = 0.8) +
  geom_point(aes(x = nCores, y = rel_speedup_omp_for,
    col = N, fill = N), size = 1.6) +
  geom_abline(slope = 1, intercept = 0, col="grey", linetype=2) +
  scale_x_continuous(breaks = 1:12, minor_breaks = NULL, limits = c(1,10)) +
  scale_y_continuous(breaks = seq(0, 7, by=1), limits = c(0.5,7)) +
  scale_fill_manual(values = fill_colors) +
  scale_color_manual(values = colors)+
  xlab("Number of cores") + ylab("Multiple core speed-up [times]")

```

