# Odd Even Sorting Implementation

Marius Wichtner, Anton Beck, Akif Bagci,
Eren Albayrak

02.02.2018

FRANKFURT
UNIVERSITY
OF APPLIED SCIENCES

# Overview



Introduction

Algorithm

Implementation

Scalability

Conclusion

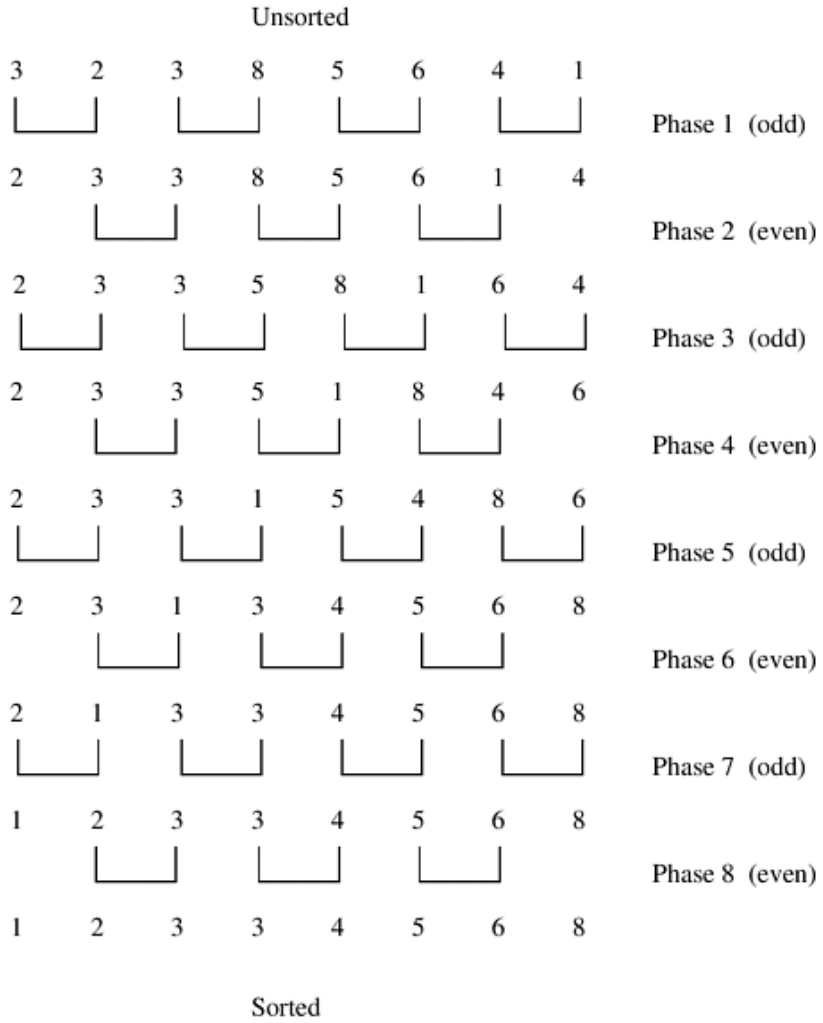
# Introduction



- Team
- Motivation
- Task

# Algorithm - Not Parallel





# Parallel Implementation



| t | P0 | | P1 | | P2 | | P3 | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 7 | 6 | 3 | 9 | 1 | 8 | 4 | 2 | |
| 1 | 3 | 6 | 7 | 9 | 1 | 2 | 4 | 8 | even |
| 2 | 3 | 6 | 1 | 2 | 7 | 9 | 4 | 8 | odd |
| 3 | 1 | 2 | 3 | 6 | 4 | 7 | 8 | 9 | even |
| 4 | 1 | 2 | 3 | 4 | 6 | 7 | 8 | 9 | odd |

# Profiling Python



5 cores -> 45.000.000 digits

```
 ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     10    5.896    0.590    5.896    0.590 {method 'sort' of 'numpy.ndarray' objects}
      5    2.585    0.517    2.585    0.517 {method 'Sendrecv' of 'mpi4py.MPI.Comm' objects}
     40    1.246    0.031    1.246    0.031 {method 'copy' of 'numpy.ndarray' objects}
      5    0.853    0.171    0.853    0.171 {built-in method numpy.core.multiarray.concatenate}
      1    0.753    0.753    0.753    0.753 {method 'Gather' of 'mpi4py.MPI.Comm' objects}
     11    0.666    0.061    0.671    0.061 {built-in method _imp.create_dynamic}
      1    0.535    0.535    0.535    0.535 {built-in method numpy.core.multiarray.fromfile}
      1    0.150    0.150   10.826   10.826 parallel-odd-even-sort.py:42(do_odd_even_sort)
```

15 cores -> 45.000.000 digits

```
ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     8    7.713    0.964    7.713    0.964 {method 'Sendrecv' of 'mpi4py.MPI.Comm' objects}
     8    3.393    0.424    3.393    0.424 {method 'sort' of 'numpy.ndarray' objects}
    11    1.952    0.177    1.957    0.178 {built-in method _imp.create_dynamic}
     1    1.503    1.503    1.503    1.503 {built-in method numpy.core.multiarray.fromfile}
     1    1.058    1.058    1.058    1.058 {method 'Gather' of 'mpi4py.MPI.Comm' objects}
    38    0.707    0.019    0.707    0.019 {method 'copy' of 'numpy.ndarray' objects}
    10    0.645    0.065    0.645    0.065 {built-in method numpy.core.multiarray.concatenate}
```

# MPI with C++ & vector Advices

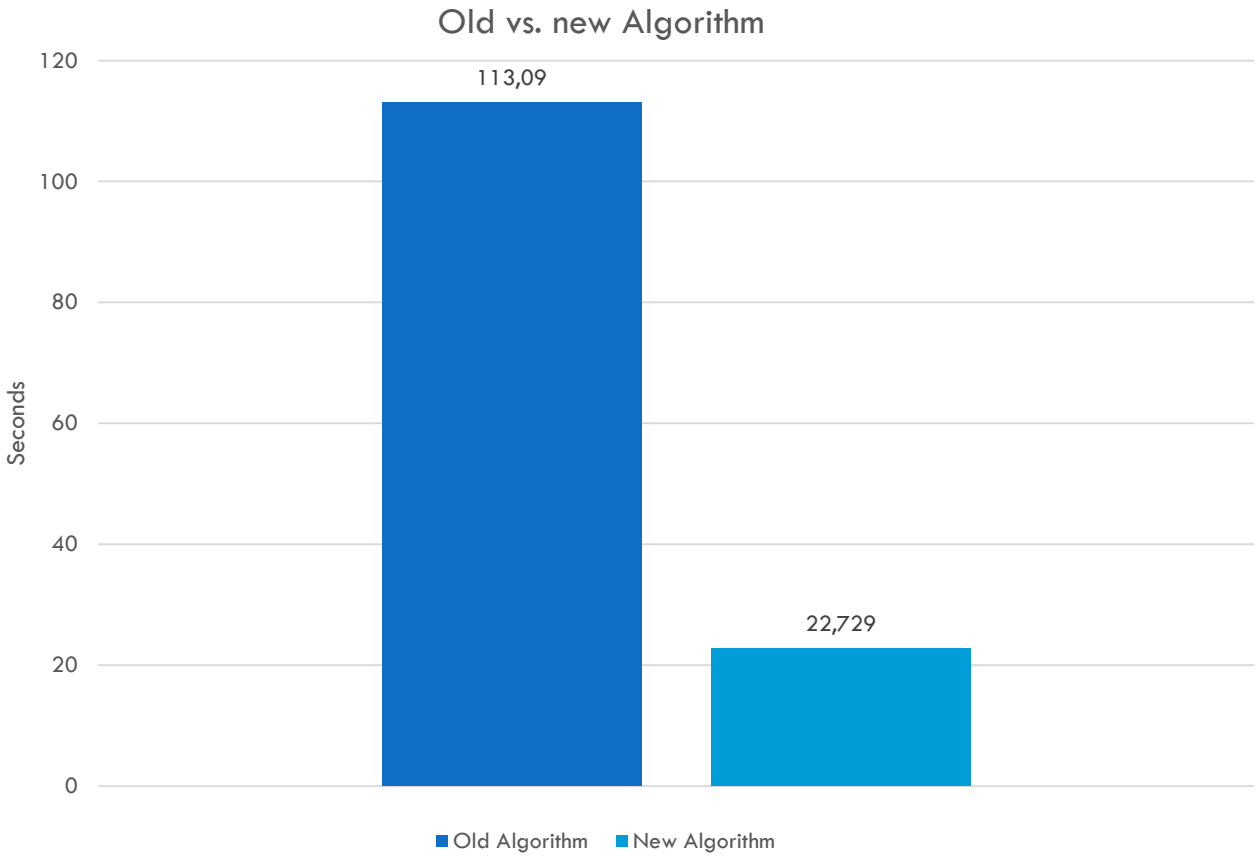


- Read complexity of every method you use
  - Insert/delete elements at position x: O(n)
    n = elements which have to move
  - Deleting triggers reduction of container size too
- Use: vector.at(i++) = value
  instead: vector.push_back(value)
  Because by larger sizes ( >1gb ): bad alloc exception
- Filling in arrays is faster than in vectors
- Memory allocation for big sizes: dynamic, not static

# MPI with C++ & vector Advices



- Old Algorithm: 500 nodes and 5.119.997
- New Algorithm: 480 nodes and 4.800.000



# Scalability

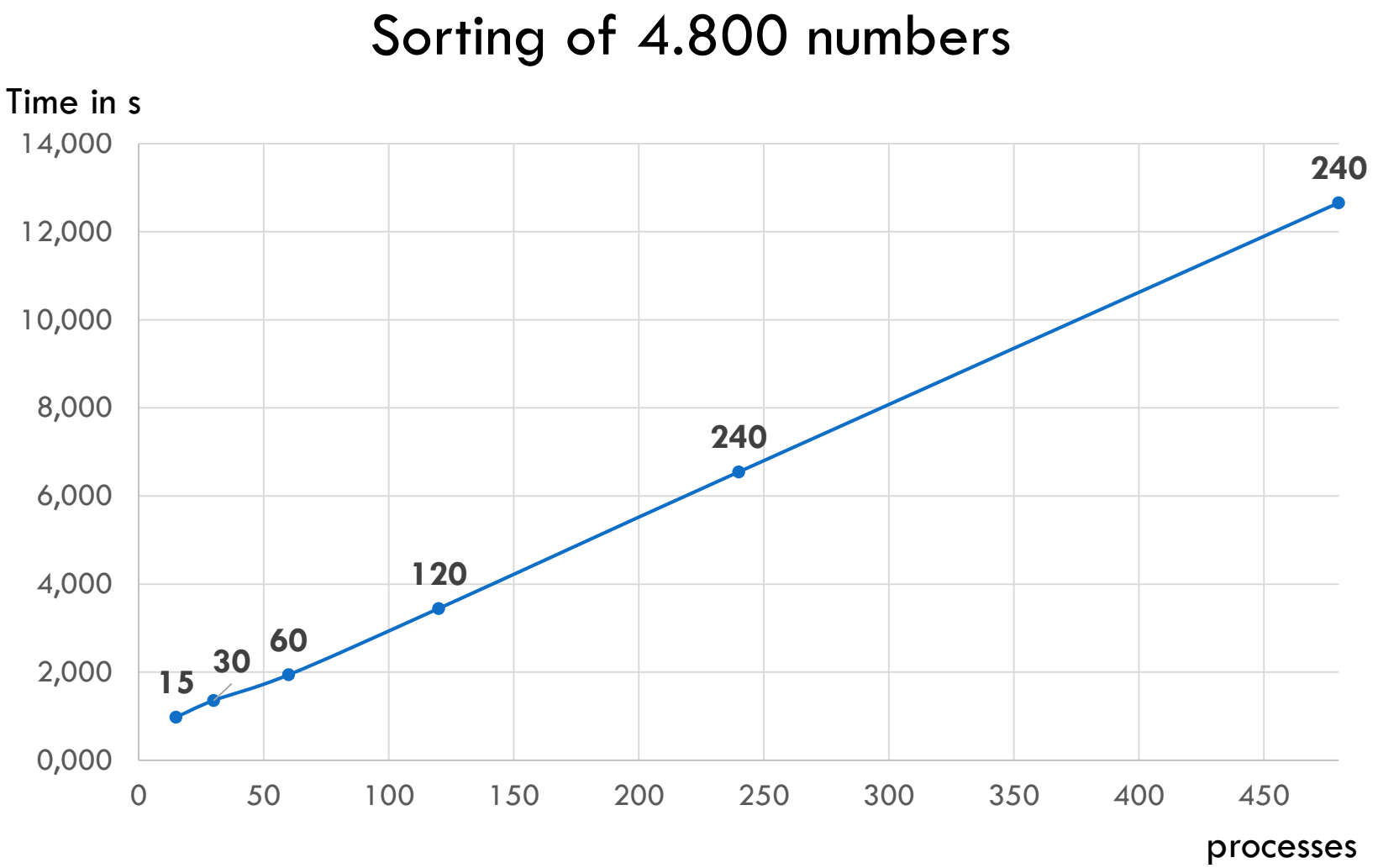


Required time for sorting in seconds

| Count Processes: | 15 | 30 | 60 | 120 | 240 | 480 |
|---|---|---|---|---|---|---|
| **4.800** | 0,976 | 1,355 | 1,938 | 3,444 | 6,545 | 12,657 |
| **48.000** | 1,027 | 1,368 | 2,064 | 3,539 | 6,775 | 12,711 |
| **480.000** | 1,630 | 2,001 | 2,662 | 4,071 | 7,441 | 13,651 |
| **4.800.000** | 7,566 | 7,840 | 8,545 | 11,537 | 15,479 | 22,729 |
| **48.000.000** | 71,458 | 71,589 | 71,076 | 75,547 | 103,359 | 105,701 |
| **480.000.000** | | | 922,072 | 924,685 | 956,681 | 720,331 |

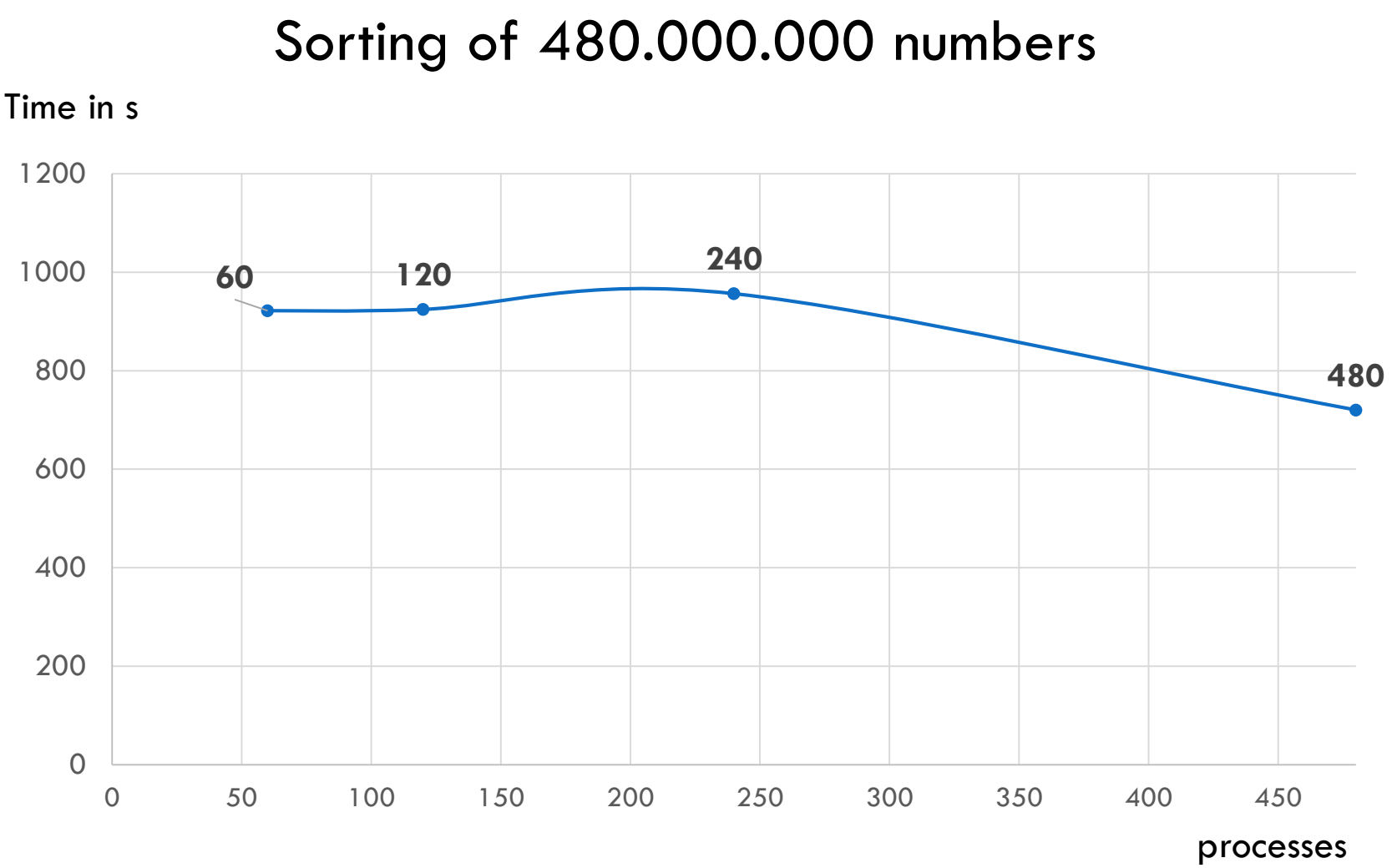
# Scalability





# Scalability





# Scalability



## Speed: digits / nodes / seconds

I.e: For 4.800 digits with 15 nodes, each node sort in 1 sec. 327,869 digits

| | 15 | 30 | 60 | 120 | 240 | 480 |
|---|---|---|---|---|---|---|
| **4.800** | 327,869 | 118,081 | 41,280 | 11,614 | 3,056 | 0,790 |
| **48.000** | 3.115,871 | 1.169,591 | 387,597 | 113,026 | 29,520 | 7,867 |
| **480.000** | 19.631,902 | 7.996,002 | 3.005,259 | 982,560 | 268,781 | 73,255 |
| **4.800.000** | 42.294,475 | 20.408,163 | 9.362,200 | 3.467,106 | 1.292,073 | 439,967 |
| **48.000.000** | 44.781,550 | 22.349,802 | 11.255,557 | 5.294,717 | 1.935,003 | 946,065 |
| **480.000.000** | | | 8.676,112 | 4.325,797 | 2.090,561 | 1.388,251 |

# Scalability

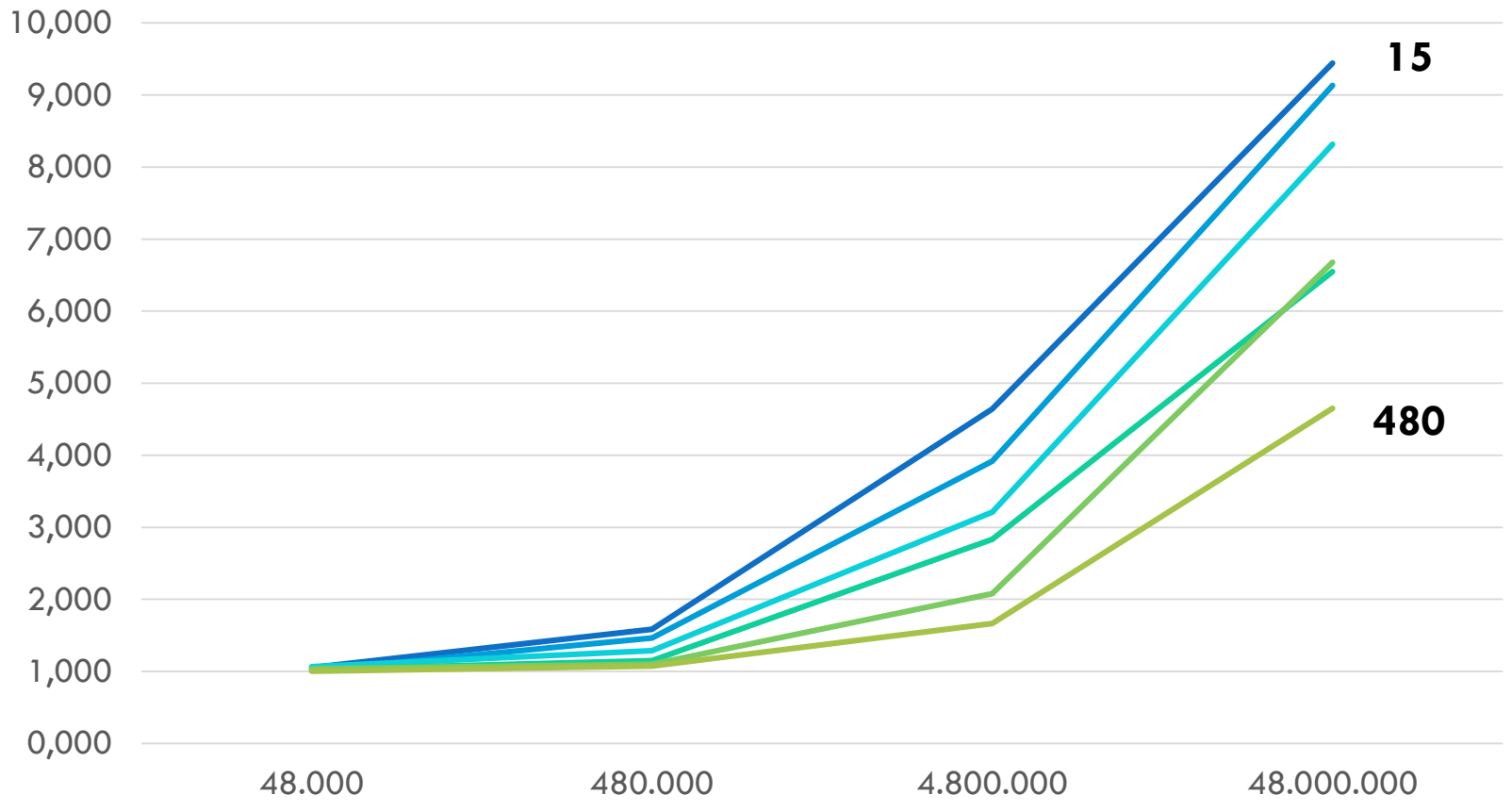


## Scaling factors

| | 15 | 30 | 60 | 120 | 240 | 480 |
|---|---|---|---|---|---|---|
| **4.800** | - | - | - | - | - | - |
| **48.000** | 1,052 | 1,010 | 1,065 | 1,028 | 1,035 | 1,004 |
| **480.000** | 1,587 | 1,463 | 1,290 | 1,150 | 1,098 | 1,074 |
| **4.800.000** | 4,642 | 3,918 | 3,210 | 2,834 | 2,080 | 1,665 |
| **48.000.000** | 9,445 | 9,131 | 8,318 | 6,548 | 6,677 | 4,650 |
| **480.000.000** | - | - | 12,973 | 12,240 | 9,256 | 6,815 |

# Scalability





# Conclusion



# Image Sources



- http://www.hedgeco.net/news/wp-content/uploads/2010/08/pic-page31.jpg
- https://www.geeksforgeeks.org/wp-content/uploads/Even-Odd-Sort.gif

Our Github Repo: https://github.com/erenalbayrak/Odd-Even-Sort-mit-MPI