Algoritmos e Estruturas de Dados

2020/2021

Trabalho 2

Estudo de rotinas de ordenação

David Ferreira, 98608 (50%);

Pedro Ferreira, 98620 (50%)

Introdução

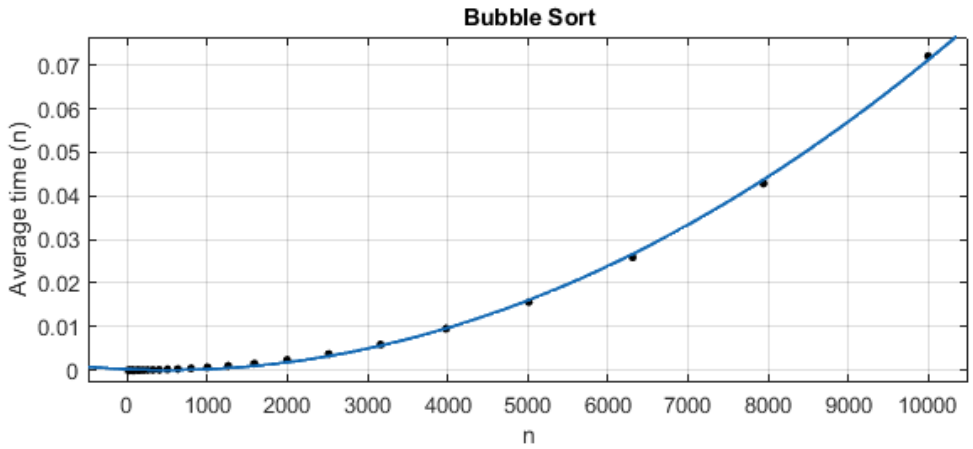
Este trabalho consiste em testar os diferentes tempos das rotinas de ordenação, fazendo variar o número de elementos a ser ordenado e os elementos em si.

Para tal, foram gerados diferentes arrays com números inteiros aleatórios. Para o número de elementos de cada array, foram gerados números aleatórios 100 vezes e ordenados por todos os métodos de ordenação fornecidos e calculados os respetivos tempos de execução.

Resultados

(tabelas em apêndice)

- **Bubble Sort**

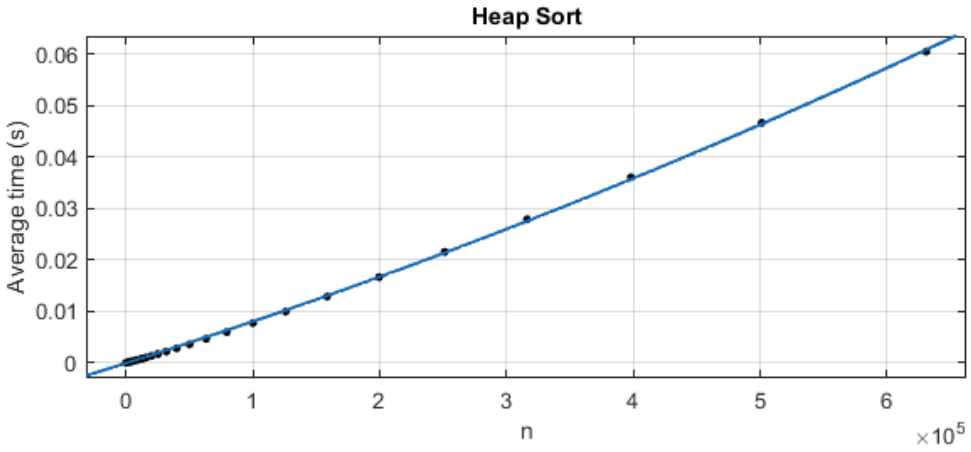


Equação aproximada do gráfico:

f(x) = a*x^2 + b*x + c
(eq. polinomial)

a = 0.005124 (0.004986, 0.005263)
b = 0.0043 (0.003992, 0.004608)
c = 0.0009287 (0.0007313, 0.001126)

- **Heap Sort**

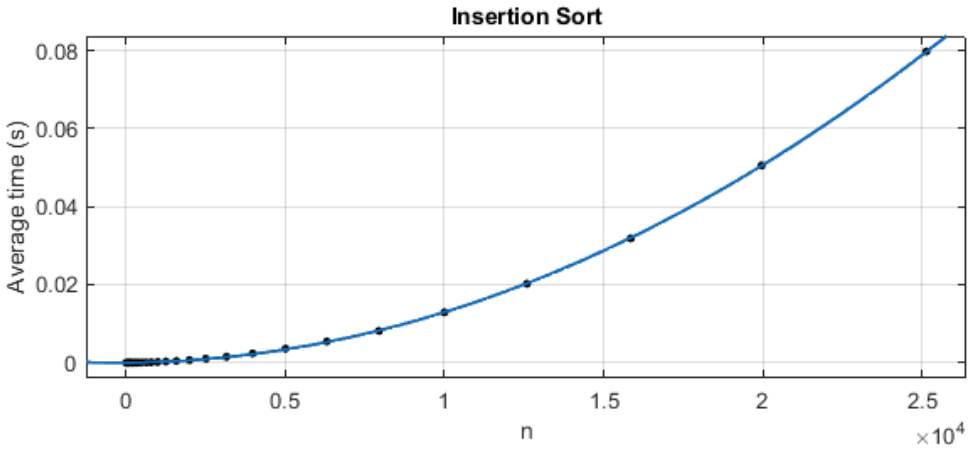


Equação aproximada do gráfico:

f(x) = a*x + b
(eq. linear)

a = 0.01256 (0.01236, 0.01277)
b = 0.005427 (0.005226, 0.005628)

- **Insertion Sort**

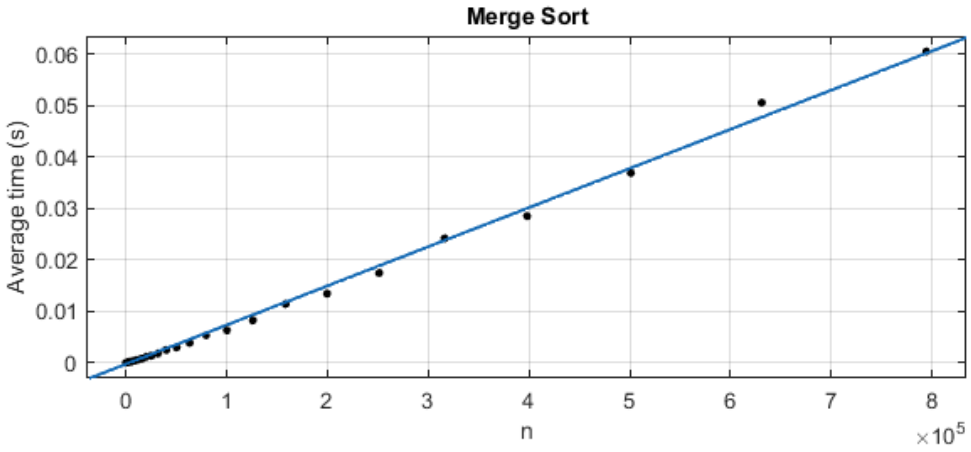


Equação aproximada do gráfico:

f(x) = a*x^2 + b*x + c
(eq. polinomial)

a = 0.00469 (0.004666, 0.004713)
b = 0.005632 (0.005575, 0.005689)
c = 0.001701 (0.001666, 0.001736)

- **Merge Sort**

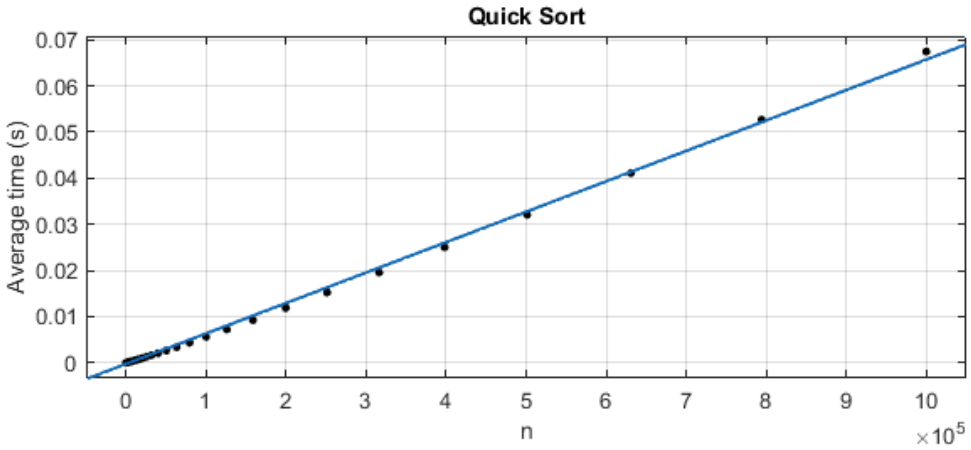


Equação aproximada do gráfico:

f(x) = a*x + b
(eq. linear)

a = 0.01293 (0.01274, 0.01312)
b = 0.005604 (0.005415, 0.005792)

- **Quick Sort**

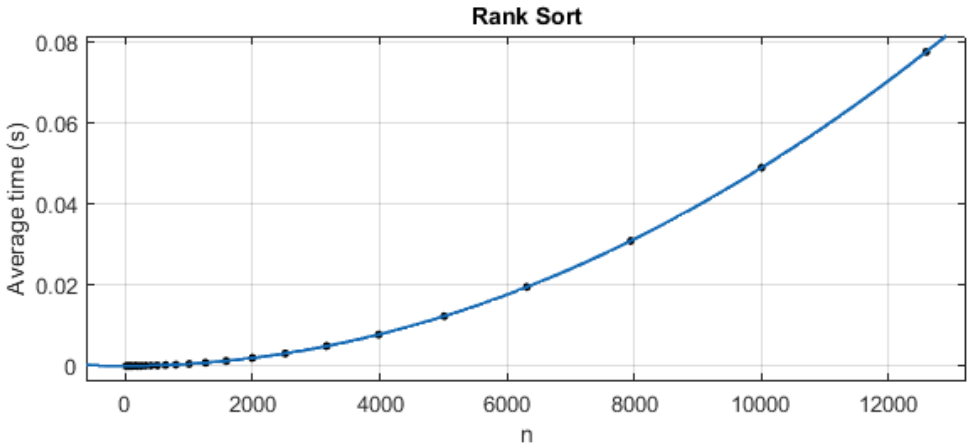


Equação aproximada do gráfico:

f(x) = a*x + b
(eq. linear)

a = 0.01398 (0.01383, 0.01413)
b = 0.006005 (0.00586, 0.00615)

- **Rank Sort**

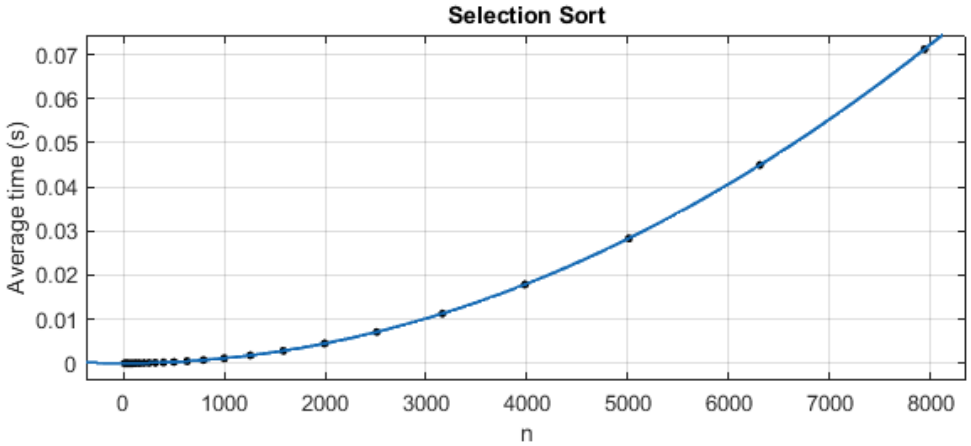


Equação aproximada do gráfico:

f(x) = a*x^2 + b*x + c
(eq. polinomial)

a = 0.004951 (0.00495, 0.004952)
b = 0.005938 (0.005936, 0.00594)
c = 0.001781 (0.00178, 0.001782)

- **Selection Sort**

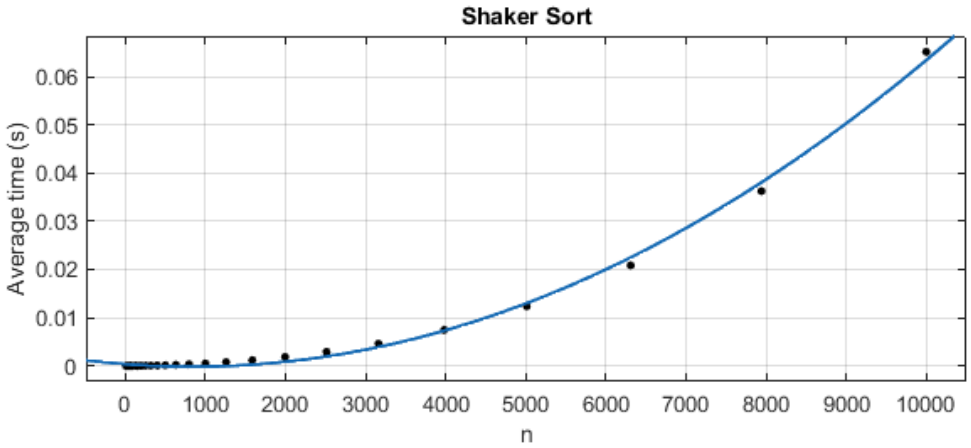


Equação aproximada do gráfico:

f(x) = a*x^2 + b*x + c
(eq. polinomial)

a = 0.004736 (0.004735, 0.004737)
b = 0.005913 (0.005911, 0.005916)
c = 0.001849 (0.001847, 0.00185)

- **Shaker Sort**

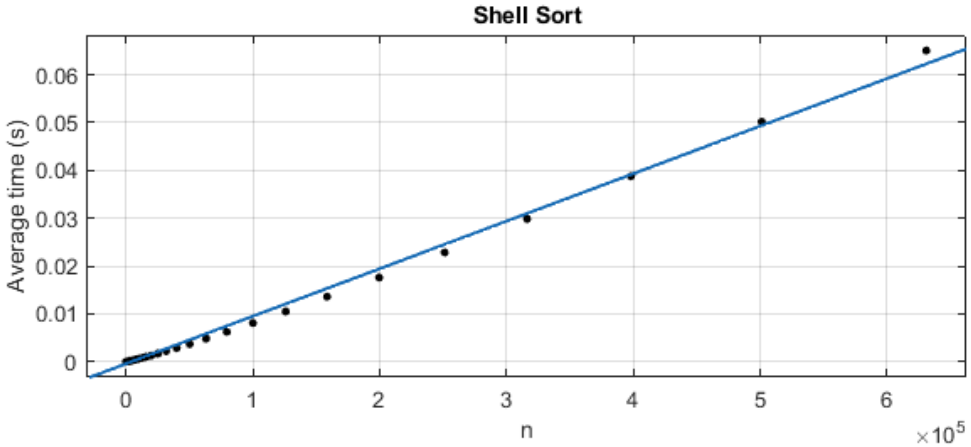


Equação aproximada do gráfico:

f(x) = a*x^2 + b*x + c
(eq. polinomial)

a = 0.004924 (0.004662, 0.005185)
b = 0.002801 (0.00222, 0.003382)
c = 0.0002295 (-0.000143, 0.000602)

- **Shell Sort**



Equação aproximada do gráfico:

f(x) = a*x + b
(eq. linear)

a = 0.01351 (0.01327, 0.01375)
b = 0.00579 (0.005553, 0.006028)

Conclusão

De acordo com os nosso resultados, os melhores algoritmos são:

- Para poucos dados de entrada: Merge Sort
  - complexidade temporal: $\Theta(n^2)$
  - complexidade espacial: O(n)

- Para muitos dados de entrada: Quick Sort
  - complexidade temporal: Θ(nlog n)
  - complexidade espacial: O(nlog n)

- Mais simples (menos linhas de código): Insertion Sort (cerca de 7 linhas)
  - complexidade temporal: $\Theta(n^2)$
  - complexidade espacial: O(n)

Os valores obtidos de tempo máximo e mínimo são aproximadamente iguais à média dos valores obtidos, para todos os algoritmos.

Apêndice

Bubble Sort				
n	min time	max time	avg time	std dev
10	7.310e-07	9.420e-07	8.208e-07	5.140e-08
13	9.220e-07	1.273e-06	1.110e-06	7.907e-08
16	4.500e-07	5.920e-07	5.202e-07	3.625e-08
20	6.210e-07	8.320e-07	7.273e-07	5.122e-08
25	8.920e-07	1.171e-06	1.034e-06	6.338e-08
32	1.372e-06	1.723e-06	1.549e-06	8.548e-08
40	2.024e-06	2.505e-06	2.260e-06	1.156e-07
50	2.976e-06	3.647e-06	3.325e-06	1.539e-07
63	4.579e-06	5.390e-06	5.023e-06	1.952e-07
79	6.994e-06	8.105e-06	7.588e-06	2.650e-07
100	1.074e-05	1.220e-05	1.147e-05	3.605e-07
126	1.578e-05	1.768e-05	1.671e-05	4.468e-07
158	2.295e-05	2.554e-05	2.427e-05	6.147e-07
200	3.438e-05	3.787e-05	3.602e-05	7.702e-07
251	5.105e-05	5.540e-05	5.327e-05	1.027e-06
316	7.691e-05	8.272e-05	7.966e-05	1.336e-06
398	1.159e-04	1.243e-04	1.196e-04	1.816e-06
501	1.755e-04	1.887e-04	1.809e-04	2.719e-06
631	2.676e-04	2.843e-04	2.747e-04	3.707e-06
794	4.093e-04	4.309e-04	4.191e-04	4.698e-06
1000	6.285e-04	6.592e-04	6.441e-04	7.046e-06
1259	9.712e-04	1.011e-03	9.916e-04	9.189e-06
1585	1.497e-03	1.562e-03	1.533e-03	1.440e-05
1995	2.325e-03	2.425e-03	2.382e-03	2.167e-05
2512	3.614e-03	3.784e-03	3.719e-03	3.517e-05
3162	5.734e-03	6.069e-03	5.877e-03	6.889e-05
3981	9.196e-03	9.953e-03	9.538e-03	1.776e-04
5012	1.516e-02	1.632e-02	1.566e-02	2.799e-04
6310	2.527e-02	2.660e-02	2.592e-02	3.420e-04
7943	4.216e-02	4.361e-02	4.288e-02	3.517e-04
10000	7.136e-02	7.294e-02	7.214e-02	3.820e-04

Heap Sort				
n	min time	max time	avg time	std dev
10	2.510e-07	3.200e-07	2.777e-07	1.295e-08
13	3.100e-07	3.710e-07	3.402e-07	1.569e-08
16	3.710e-07	4.510e-07	4.112e-07	1.844e-08
20	4.610e-07	5.520e-07	5.066e-07	2.145e-08
25	5.910e-07	6.920e-07	6.394e-07	2.443e-08
32	7.810e-07	9.020e-07	8.396e-07	2.984e-08
40	1.002e-06	1.132e-06	1.066e-06	3.162e-08
50	1.302e-06	1.453e-06	1.376e-06	3.725e-08
63	1.713e-06	1.894e-06	1.801e-06	4.485e-08
79	2.234e-06	2.435e-06	2.330e-06	4.724e-08
100	2.965e-06	3.196e-06	3.077e-06	5.497e-08
126	3.927e-06	4.189e-06	4.057e-06	6.248e-08
158	5.099e-06	5.430e-06	5.261e-06	7.548e-08
200	6.763e-06	7.134e-06	6.933e-06	8.807e-08
251	8.887e-06	9.337e-06	9.103e-06	1.028e-07
316	1.168e-05	1.218e-05	1.192e-05	1.180e-07
398	1.537e-05	1.595e-05	1.564e-05	1.355e-07
501	2.020e-05	2.088e-05	2.053e-05	1.505e-07
631	2.632e-05	2.714e-05	2.669e-05	1.812e-07
794	3.436e-05	3.524e-05	3.476e-05	2.060e-07
1000	4.494e-05	4.601e-05	4.544e-05	2.471e-07
1259	5.830e-05	5.964e-05	5.889e-05	2.863e-07
1585	7.595e-05	7.789e-05	7.660e-05	3.338e-07
1995	9.873e-05	1.029e-04	9.958e-05	5.054e-07
2512	1.280e-04	1.327e-04	1.290e-04	6.974e-07
3162	1.662e-04	1.717e-04	1.674e-04	9.566e-07
3981	2.154e-04	2.276e-04	2.169e-04	1.471e-06
5012	2.783e-04	2.912e-04	2.803e-04	2.194e-06
6310	3.603e-04	3.742e-04	3.626e-04	2.751e-06
7943	4.656e-04	4.801e-04	4.687e-04	3.303e-06
10000	6.011e-04	6.177e-04	6.053e-04	4.073e-06
12589	7.758e-04	7.932e-04	7.813e-04	4.666e-06
15849	1.002e-03	1.021e-03	1.009e-03	5.187e-06
19953	1.290e-03	1.310e-03	1.298e-03	5.748e-06
25119	1.664e-03	1.685e-03	1.673e-03	5.988e-06
31623	2.145e-03	2.171e-03	2.157e-03	6.691e-06
39811	2.764e-03	2.794e-03	2.779e-03	6.942e-06
50119	3.567e-03	3.592e-03	3.580e-03	5.606e-06
63096	4.601e-03	4.636e-03	4.614e-03	8.199e-06
79433	5.932e-03	5.974e-03	5.950e-03	9.447e-06
100000	7.660e-03	7.702e-03	7.677e-03	8.694e-06
125893	9.896e-03	9.966e-03	9.922e-03	1.410e-05
158489	1.280e-02	1.297e-02	1.284e-02	2.885e-05
199526	1.657e-02	1.678e-02	1.661e-02	3.108e-05
251189	2.145e-02	2.179e-02	2.151e-02	6.066e-05
316228	2.776e-02	2.826e-02	2.784e-02	8.751e-05
398107	3.589e-02	3.643e-02	3.600e-02	1.232e-04
501187	4.645e-02	4.716e-02	4.660e-02	1.578e-04
630957	6.023e-02	6.112e-02	6.042e-02	2.032e-04

Insertion Sort				
n	min time	max time	avg time	std dev
10	2.200e-07	2.610e-07	2.381e-07	1.016e-08
13	2.500e-07	2.910e-07	2.679e-07	1.069e-08
16	2.810e-07	3.210e-07	3.029e-07	1.043e-08
20	3.300e-07	3.800e-07	3.500e-07	1.199e-08
25	3.900e-07	4.610e-07	4.173e-07	1.700e-08
32	4.810e-07	5.810e-07	5.327e-07	2.433e-08
40	6.010e-07	7.520e-07	6.795e-07	3.615e-08
50	7.810e-07	9.920e-07	8.849e-07	5.510e-08
63	1.042e-06	1.373e-06	1.211e-06	9.122e-08
79	1.463e-06	1.934e-06	1.724e-06	1.271e-07
100	2.094e-06	2.845e-06	2.540e-06	1.905e-07
126	3.016e-06	4.228e-06	3.699e-06	3.556e-07
158	4.338e-06	6.261e-06	5.397e-06	6.140e-07
200	6.412e-06	9.378e-06	7.880e-06	1.080e-06
251	9.588e-06	1.439e-05	1.229e-05	1.727e-06
316	1.447e-05	2.207e-05	1.846e-05	2.840e-06
398	2.216e-05	3.390e-05	2.947e-05	4.275e-06
501	3.413e-05	5.275e-05	4.456e-05	7.308e-06
631	5.315e-05	8.227e-05	7.115e-05	1.112e-05
794	8.209e-05	1.277e-04	1.041e-04	1.905e-05
1000	1.297e-04	2.007e-04	1.772e-04	2.657e-05
1259	2.028e-04	3.141e-04	2.625e-04	4.727e-05
1585	3.209e-04	4.941e-04	4.390e-04	6.610e-05
1995	5.044e-04	7.758e-04	6.599e-04	1.145e-04
2512	7.954e-04	1.221e-03	9.974e-04	1.834e-04
3162	1.255e-03	1.923e-03	1.526e-03	2.754e-04
3981	1.990e-03	3.021e-03	2.350e-03	3.797e-04
5012	3.147e-03	4.287e-03	3.569e-03	4.015e-04
6310	4.990e-03	6.330e-03	5.428e-03	4.431e-04
7943	7.891e-03	9.197e-03	8.124e-03	2.532e-04
10000	1.251e-02	1.384e-02	1.287e-02	3.659e-04
12589	1.985e-02	2.122e-02	2.021e-02	3.117e-04
15849	3.145e-02	3.244e-02	3.184e-02	2.166e-04
19953	4.986e-02	5.147e-02	5.052e-02	4.405e-04
25119	7.905e-02	8.051e-02	7.969e-02	3.528e-04

Merge Sort				
n	min time	max time	avg time	std dev
10	2.200e-07	2.600e-07	2.363e-07	9.159e-09
13	2.500e-07	2.910e-07	2.672e-07	9.820e-09
16	2.800e-07	3.210e-07	2.984e-07	1.043e-08
20	3.210e-07	3.710e-07	3.459e-07	1.265e-08
25	3.810e-07	4.510e-07	4.100e-07	1.681e-08
32	4.710e-07	5.710e-07	5.151e-07	2.561e-08
40	7.010e-07	7.910e-07	7.446e-07	2.075e-08
50	8.910e-07	9.920e-07	9.409e-07	2.494e-08
63	1.152e-06	1.282e-06	1.216e-06	3.068e-08
79	1.553e-06	1.724e-06	1.642e-06	4.014e-08
100	2.014e-06	2.184e-06	2.097e-06	3.910e-08
126	2.595e-06	2.826e-06	2.696e-06	5.111e-08
158	3.587e-06	3.978e-06	3.771e-06	1.071e-07
200	4.809e-06	5.309e-06	4.974e-06	1.083e-07
251	6.362e-06	7.304e-06	6.958e-06	2.307e-07
316	8.356e-06	8.827e-06	8.566e-06	1.077e-07
398	1.120e-05	1.218e-05	1.150e-05	2.042e-07
501	1.451e-05	1.655e-05	1.539e-05	5.508e-07
631	1.942e-05	2.186e-05	2.034e-05	5.109e-07
794	2.552e-05	2.642e-05	2.592e-05	2.003e-07
1000	3.436e-05	3.862e-05	3.681e-05	1.143e-06
1259	4.345e-05	4.969e-05	4.493e-05	1.513e-06
1585	5.763e-05	6.108e-05	5.866e-05	7.960e-07
1995	7.394e-05	8.321e-05	7.644e-05	2.181e-06
2512	9.658e-05	1.066e-04	9.849e-05	2.067e-06
3162	1.283e-04	1.338e-04	1.300e-04	1.433e-06
3981	1.649e-04	1.785e-04	1.686e-04	3.072e-06
5012	2.141e-04	2.380e-04	2.220e-04	6.962e-06
6310	2.834e-04	2.965e-04	2.859e-04	2.244e-06
7943	3.641e-04	4.019e-04	3.741e-04	8.863e-06
10000	4.718e-04	5.309e-04	5.056e-04	1.399e-05
12589	6.200e-04	6.398e-04	6.264e-04	5.339e-06
15849	7.957e-04	8.402e-04	8.089e-04	9.909e-06
19953	1.090e-03	1.170e-03	1.130e-03	2.058e-05
25119	1.346e-03	1.382e-03	1.357e-03	8.243e-06
31623	1.728e-03	1.860e-03	1.759e-03	2.823e-05
39811	2.373e-03	2.594e-03	2.475e-03	6.125e-05
50119	2.906e-03	2.979e-03	2.940e-03	2.256e-05
63096	3.734e-03	4.022e-03	3.847e-03	7.832e-05
79433	5.159e-03	5.538e-03	5.348e-03	9.483e-05
100000	6.256e-03	6.353e-03	6.302e-03	2.411e-05
125893	8.049e-03	8.477e-03	8.226e-03	1.064e-04
158489	1.110e-02	1.176e-02	1.143e-02	1.688e-04
199526	1.338e-02	1.352e-02	1.344e-02	3.327e-05
251189	1.720e-02	1.795e-02	1.748e-02	1.686e-04
316228	2.362e-02	2.479e-02	2.422e-02	3.046e-04
398107	2.844e-02	2.864e-02	2.854e-02	4.756e-05
501187	3.656e-02	3.760e-02	3.693e-02	2.373e-04
630957	4.967e-02	5.176e-02	5.063e-02	5.051e-04
794328	6.043e-02	6.074e-02	6.058e-02	7.463e-05

Quick Sort				
n	min time	max time	avg time	std dev
10	2.200e-07	2.610e-07	2.377e-07	9.779e-09
13	2.500e-07	2.910e-07	2.684e-07	9.654e-09
16	2.810e-07	3.310e-07	3.040e-07	1.107e-08
20	3.610e-07	4.210e-07	3.906e-07	1.473e-08
25	4.310e-07	5.120e-07	4.690e-07	1.948e-08
32	5.410e-07	6.610e-07	5.993e-07	2.833e-08
40	7.020e-07	8.210e-07	7.585e-07	2.681e-08
50	8.920e-07	1.042e-06	9.663e-07	3.385e-08
63	1.163e-06	1.362e-06	1.259e-06	4.350e-08
79	1.533e-06	1.744e-06	1.634e-06	5.132e-08
100	2.034e-06	2.284e-06	2.153e-06	6.018e-08
126	2.675e-06	2.996e-06	2.829e-06	7.004e-08
158	3.517e-06	3.887e-06	3.697e-06	8.741e-08
200	4.659e-06	5.119e-06	4.883e-06	1.059e-07
251	6.122e-06	6.663e-06	6.387e-06	1.284e-07
316	8.055e-06	8.727e-06	8.383e-06	1.553e-07
398	1.057e-05	1.138e-05	1.099e-05	1.897e-07
501	1.389e-05	1.491e-05	1.442e-05	2.407e-07
631	1.824e-05	1.956e-05	1.890e-05	3.058e-07
794	2.388e-05	2.547e-05	2.469e-05	3.706e-07
1000	3.131e-05	3.329e-05	3.229e-05	4.650e-07
1259	4.084e-05	4.341e-05	4.213e-05	6.093e-07
1585	5.335e-05	5.659e-05	5.497e-05	7.589e-07
1995	6.960e-05	7.401e-05	7.165e-05	1.000e-06
2512	9.059e-05	9.684e-05	9.332e-05	1.244e-06
3162	1.180e-04	1.255e-04	1.212e-04	1.545e-06
3981	1.532e-04	1.630e-04	1.574e-04	1.980e-06
5012	1.988e-04	2.116e-04	2.041e-04	2.546e-06
6310	2.583e-04	2.742e-04	2.645e-04	3.187e-06
7943	3.340e-04	3.539e-04	3.424e-04	4.274e-06
10000	4.330e-04	4.557e-04	4.433e-04	5.324e-06
12589	5.607e-04	5.880e-04	5.736e-04	6.321e-06
15849	7.238e-04	7.574e-04	7.398e-04	7.968e-06
19953	9.356e-04	9.759e-04	9.557e-04	9.843e-06
25119	1.207e-03	1.257e-03	1.233e-03	1.197e-05
31623	1.555e-03	1.618e-03	1.587e-03	1.522e-05
39811	2.007e-03	2.082e-03	2.045e-03	1.858e-05
50119	2.581e-03	2.676e-03	2.633e-03	2.327e-05
63096	3.328e-03	3.440e-03	3.388e-03	2.822e-05
79433	4.278e-03	4.422e-03	4.355e-03	3.447e-05
100000	5.503e-03	5.689e-03	5.596e-03	4.477e-05
125893	7.074e-03	7.295e-03	7.192e-03	5.693e-05
158489	9.077e-03	9.372e-03	9.230e-03	7.295e-05
199526	1.166e-02	1.203e-02	1.185e-02	9.100e-05
251189	1.497e-02	1.544e-02	1.522e-02	1.153e-04
316228	1.920e-02	1.981e-02	1.953e-02	1.476e-04
398107	2.464e-02	2.538e-02	2.501e-02	1.786e-04
501187	3.153e-02	3.251e-02	3.206e-02	2.329e-04
630957	4.044e-02	4.167e-02	4.108e-02	2.900e-04
794328	5.183e-02	5.333e-02	5.263e-02	3.667e-04
1000000	6.644e-02	6.834e-02	6.741e-02	4.604e-04

Rank Sort				
n	min time	max time	avg time	std dev
10	2.100e-07	2.410e-07	2.154e-07	6.004e-09
13	2.300e-07	2.510e-07	2.398e-07	5.078e-09
16	2.600e-07	2.910e-07	2.727e-07	6.293e-09
20	3.110e-07	3.410e-07	3.254e-07	7.329e-09
25	3.910e-07	4.410e-07	4.169e-07	1.159e-08
32	5.510e-07	6.120e-07	5.781e-07	1.606e-08
40	7.610e-07	8.620e-07	8.123e-07	2.347e-08
50	1.133e-06	1.273e-06	1.204e-06	3.313e-08
63	1.763e-06	1.974e-06	1.871e-06	5.082e-08
79	2.755e-06	3.105e-06	2.916e-06	8.117e-08
100	4.448e-06	4.969e-06	4.700e-06	1.275e-07
126	7.003e-06	7.865e-06	7.437e-06	1.999e-07
158	1.108e-05	1.237e-05	1.171e-05	3.069e-07
200	1.791e-05	1.979e-05	1.882e-05	4.399e-07
251	2.853e-05	3.127e-05	2.985e-05	6.337e-07
316	4.554e-05	4.974e-05	4.752e-05	9.803e-07
398	7.305e-05	7.907e-05	7.588e-05	1.410e-06
501	1.162e-04	1.262e-04	1.205e-04	2.143e-06
631	1.859e-04	2.002e-04	1.921e-04	3.168e-06
794	2.963e-04	3.169e-04	3.049e-04	4.542e-06
1000	4.730e-04	4.995e-04	4.850e-04	6.347e-06
1259	7.517e-04	7.890e-04	7.707e-04	8.963e-06
1585	1.199e-03	1.248e-03	1.224e-03	1.172e-05
1995	1.905e-03	1.979e-03	1.941e-03	1.807e-05
2512	3.037e-03	3.133e-03	3.081e-03	2.339e-05
3162	4.821e-03	4.958e-03	4.889e-03	3.259e-05
3981	7.657e-03	7.852e-03	7.753e-03	4.596e-05
5012	1.216e-02	1.244e-02	1.230e-02	6.642e-05
6310	1.931e-02	1.969e-02	1.950e-02	9.087e-05
7943	3.067e-02	3.121e-02	3.093e-02	1.288e-04
10000	4.867e-02	4.943e-02	4.905e-02	1.820e-04
12589	7.717e-02	7.826e-02	7.774e-02	2.642e-04

Selection Sort				
n	min time	max time	avg time	std dev
10	2.700e-07	3.100e-07	2.840e-07	9.247e-09
13	3.410e-07	3.810e-07	3.639e-07	9.006e-09
16	4.410e-07	4.910e-07	4.630e-07	9.017e-09
20	6.110e-07	6.510e-07	6.292e-07	9.321e-09
25	8.620e-07	9.020e-07	8.839e-07	8.810e-09
32	1.313e-06	1.353e-06	1.334e-06	9.216e-09
40	1.963e-06	2.004e-06	1.984e-06	9.747e-09
50	2.975e-06	3.016e-06	2.997e-06	1.063e-08
63	4.629e-06	4.679e-06	4.655e-06	1.174e-08
79	7.173e-06	7.244e-06	7.215e-06	1.218e-08
100	1.125e-05	1.148e-05	1.144e-05	2.582e-08
126	1.773e-05	1.812e-05	1.807e-05	5.113e-08
158	2.760e-05	2.836e-05	2.827e-05	1.317e-07
200	4.424e-05	4.531e-05	4.514e-05	2.362e-07
251	6.974e-05	7.127e-05	7.095e-05	3.969e-07
316	1.106e-04	1.155e-04	1.122e-04	7.371e-07
398	1.758e-04	1.856e-04	1.777e-04	1.168e-06
501	2.781e-04	2.920e-04	2.812e-04	2.175e-06
631	4.412e-04	4.564e-04	4.451e-04	3.203e-06
794	6.993e-04	7.160e-04	7.041e-04	4.316e-06
1000	1.112e-03	1.129e-03	1.118e-03	5.205e-06
1259	1.766e-03	1.785e-03	1.775e-03	5.965e-06
1585	2.805e-03	2.826e-03	2.817e-03	5.621e-06
1995	4.462e-03	4.482e-03	4.470e-03	4.262e-06
2512	7.082e-03	7.106e-03	7.096e-03	5.799e-06
3162	1.124e-02	1.126e-02	1.125e-02	5.964e-06
3981	1.784e-02	1.787e-02	1.785e-02	7.412e-06
5012	2.831e-02	2.834e-02	2.833e-02	8.183e-06
6310	4.492e-02	4.496e-02	4.494e-02	9.375e-06
7943	7.122e-02	7.127e-02	7.125e-02	1.100e-05

Shaker Sort				
n	min time	max time	avg time	std dev
10	2.500e-07	3.210e-07	2.840e-07	1.699e-08
13	3.200e-07	4.010e-07	3.587e-07	2.028e-08
16	3.910e-07	5.010e-07	4.470e-07	2.559e-08
20	5.210e-07	6.610e-07	5.926e-07	3.445e-08
25	7.110e-07	9.120e-07	8.129e-07	4.834e-08
32	1.062e-06	1.333e-06	1.199e-06	6.604e-08
40	1.523e-06	1.944e-06	1.740e-06	1.006e-07
50	2.274e-06	2.846e-06	2.574e-06	1.313e-07
63	3.497e-06	4.248e-06	3.892e-06	1.845e-07
79	5.320e-06	6.352e-06	5.825e-06	2.444e-07
100	8.326e-06	9.809e-06	9.057e-06	3.505e-07
126	1.259e-05	1.458e-05	1.359e-05	4.673e-07
158	1.868e-05	2.148e-05	2.001e-05	6.722e-07
200	2.814e-05	3.174e-05	2.985e-05	8.288e-07
251	4.182e-05	4.657e-05	4.408e-05	1.104e-06
316	6.252e-05	6.912e-05	6.560e-05	1.546e-06
398	9.345e-05	1.031e-04	9.778e-05	2.171e-06
501	1.410e-04	1.549e-04	1.471e-04	3.070e-06
631	2.133e-04	2.323e-04	2.217e-04	4.264e-06
794	3.245e-04	3.493e-04	3.354e-04	5.605e-06
1000	4.942e-04	5.283e-04	5.106e-04	7.836e-06
1259	7.557e-04	8.036e-04	7.793e-04	1.150e-05
1585	1.166e-03	1.230e-03	1.197e-03	1.514e-05
1995	1.801e-03	1.897e-03	1.849e-03	2.342e-05
2512	2.816e-03	2.947e-03	2.884e-03	3.172e-05
3162	4.474e-03	4.681e-03	4.571e-03	4.841e-05
3981	7.286e-03	7.640e-03	7.451e-03	8.430e-05
5012	1.213e-02	1.262e-02	1.236e-02	1.140e-04
6310	2.052e-02	2.115e-02	2.084e-02	1.471e-04
7943	3.574e-02	3.677e-02	3.624e-02	2.445e-04
10000	6.424e-02	6.602e-02	6.514e-02	4.261e-04

Shell Sort				
n	min time	max time	avg time	std dev
10	2.400e-07	2.910e-07	2.660e-07	1.274e-08
13	2.900e-07	3.600e-07	3.150e-07	1.591e-08
16	3.410e-07	4.210e-07	3.773e-07	1.808e-08
20	4.210e-07	5.210e-07	4.670e-07	2.425e-08
25	5.210e-07	6.310e-07	5.732e-07	2.456e-08
32	6.810e-07	8.020e-07	7.321e-07	3.056e-08
40	8.520e-07	1.002e-06	9.205e-07	3.460e-08
50	1.132e-06	1.303e-06	1.214e-06	4.138e-08
63	1.493e-06	1.693e-06	1.588e-06	4.821e-08
79	1.934e-06	2.174e-06	2.047e-06	5.587e-08
100	2.565e-06	2.825e-06	2.694e-06	5.882e-08
126	3.397e-06	3.677e-06	3.540e-06	6.519e-08
158	4.559e-06	4.869e-06	4.714e-06	7.527e-08
200	6.061e-06	6.432e-06	6.243e-06	8.702e-08
251	7.935e-06	8.366e-06	8.144e-06	9.912e-08
316	1.047e-05	1.096e-05	1.071e-05	1.118e-07
398	1.388e-05	1.444e-05	1.414e-05	1.314e-07
501	1.838e-05	1.907e-05	1.871e-05	1.581e-07
631	2.409e-05	2.488e-05	2.448e-05	1.789e-07
794	3.150e-05	3.252e-05	3.199e-05	2.196e-07
1000	4.117e-05	4.237e-05	4.169e-05	2.599e-07
1259	5.428e-05	5.580e-05	5.493e-05	3.337e-07
1585	7.119e-05	7.318e-05	7.201e-05	4.225e-07
1995	9.274e-05	9.562e-05	9.374e-05	5.409e-07
2512	1.209e-04	1.257e-04	1.222e-04	8.071e-07
3162	1.568e-04	1.633e-04	1.585e-04	1.134e-06
3981	2.057e-04	2.176e-04	2.081e-04	1.615e-06
5012	2.688e-04	2.823e-04	2.719e-04	2.236e-06
6310	3.482e-04	3.635e-04	3.523e-04	3.015e-06
7943	4.531e-04	4.707e-04	4.588e-04	3.807e-06
10000	5.858e-04	6.055e-04	5.930e-04	4.611e-06
12589	7.659e-04	7.902e-04	7.755e-04	5.686e-06
15849	9.961e-04	1.025e-03	1.009e-03	6.991e-06
19953	1.289e-03	1.326e-03	1.305e-03	8.966e-06
25119	1.678e-03	1.725e-03	1.699e-03	1.124e-05
31623	2.172e-03	2.228e-03	2.198e-03	1.367e-05
39811	2.817e-03	2.895e-03	2.854e-03	1.848e-05
50119	3.669e-03	3.767e-03	3.713e-03	2.311e-05
63096	4.747e-03	4.884e-03	4.806e-03	3.231e-05
79433	6.151e-03	6.339e-03	6.231e-03	4.428e-05
100000	7.975e-03	8.222e-03	8.079e-03	5.767e-05
125893	1.036e-02	1.067e-02	1.050e-02	7.707e-05
158489	1.340e-02	1.384e-02	1.359e-02	1.016e-04
199526	1.734e-02	1.794e-02	1.760e-02	1.390e-04
251189	2.248e-02	2.334e-02	2.285e-02	2.069e-04
316228	2.934e-02	3.060e-02	2.987e-02	2.966e-04
398107	3.805e-02	3.969e-02	3.880e-02	4.022e-04
501187	4.924e-02	5.136e-02	5.021e-02	5.297e-04
630957	6.382e-02	6.665e-02	6.508e-02	6.863e-04