ALGORÍTMICA

PRÁCTICA 2: ALGORITMOS DIVIDE Y VENCERÁS

Memoria final de la práctica

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ÍNDICE

En lo que sigue, los miembros del grupo combinamos sistemas operativos y maquinas diferentes para experimentar de la forma más completa y variada la eficiencia de los algoritmos. Estas son las prestaciones de las máquinas:

- Luis: Fujitsu. Intel Core i5. Ubuntu 14.04
- Ignacio: Toshiba. Intel Core i7. Ubuntu 14.04
- Diego: Mac. Intel Core i7. OS X El Capitán
- Miguel Ángel: Toshiba. Intel Core i7. Windows 10

1. Serie unimodal de números

Nuestro problema consistía en que se nos daba un vector de números que crecía estrictamente hasta un determinado índice a partir del cual decrecía de manera estricta. Debemos devolver mediante nuestros algoritmos el índice en el que dicho cambio de crecimiento se produce.

1.1 Algoritmo Evidente

En este primer algoritmo que hemos implementado para la resolución de nuestro problema hemos utilizado una versión muy simple que recorre el vector de manera secuencial. Nuestra intención es ir recorriéndolo desde la posición 0 hasta el final. Si nos encontramos un punto en el que el vector en vez de crecer decrece no continuamos avanzando ya que hemos llegado al punto que andábamos buscando, es decir, si v[i]>v[i+1] siendo el índice i el primero con el que ocurre esto.

Presentamos el código:

```
#include <iostream>
#include <vector>
#include <cstdlib>
#include <cstdio>
#include <ctime>
#include <climits>
#include <cassert>
#include <chrono>

using namespace std;

double uniforme()
{
double u;
  u = (double) rand();
  u = u/(double)(RAND_MAX+1.0);
 return u;
}

int serie_unimodal_secuencial(int *v, int n)
{
        int i=0;
        int maximo=0;
        while(v[i]<v[i+1] && ((i+1)<n))
                i++;
```

```
        //maximo=v[i];
        return i;
}

using namespace std::chrono;

int main(int argc, char * argv[])
{
  high_resolution_clock::time_point t1, t2;
  if (argc != 2)
    {
      cerr << "Formato " << argv[0] << " <num_elem>" << endl;
      return -1;
    }

  int n = atoi(argv[1]);

  int * T = new int[n];
  assert(T);

srand(time(0));
double u=uniforme();
int p=1+(int)((n-2)*u);
T[p]=n-1;
for (int i=0; i<p; i++) T[i]=i;
for (int i=p+1; i<n; i++) T[i]=n-1-i+p;

  t1=high_resolution_clock::now();
  int pos_maximo_secuencial=serie_unimodal_secuencial(T,n);
  t2=high_resolution_clock::now();
  duration<double> transcurrido = duration_cast<duration<double> >(t2-t1);
  cout << n << " " << transcurrido.count() << "\n";

  return 0;
}
```

Vemos que la eficiencia del algoritmo en este caso es lineal comparando entre sí la suma al cuadrado de los residuos de los distintos ajustes realizados.
Lineal = 9.07552e-06
nlogarítmica = 9.73699e-06
logarítmica = 7.55603e-05

Datos:
-**Tabla y gŕafica de Nacho(Toshiba,Linux):**

Tamaño	Tiempo
1	1.27e-07
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10001	1.1943e-05

15001	1.7457e-05
20001	2.3192e-05
25001	2.8999e-05
30001	3.4822e-05
35001	4.6544e-05
40001	4.6336e-05
45001	5.3974e-05
50001	5.7989e-05
55001	6.3656e-05
60001	6.9476e-05
65001	7.5713e-05
70001	8.1491e-05
75001	9.7841e-05
80001	9.3249e-05
85001	9,90E-002
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95001	0.000202677
100001	0.000213223
105001	0.000224879
110001	0.000234944
115001	0.000246068
120001	0.000269558
125001	0.000289279
130001	0.000277595
135001	0.000291965
140001	0.000311541
145001	0.000338547
150001	0.000346358
155001	0.000335746
160001	0.000348103
165001	0.000355319
170001	0.000366716
175001	0.000377835
180001	0.000387789
185001	0.000523113
190001	0.000566678
195001	0.000578435

200001	0.000590914
205001	0.000500872
210001	0.0004561
215001	0.000485209
220001	0.000505239
225001	0.000472726
230001	0.000496295
235001	0.000506936
240001	0.000628285
245001	0.000527266
250001	0.000596488
255001	0.000784005
260001	0.000766952
265001	0.000781397
270001	0.000581821
275001	0.000665732
280001	0.000651741
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290001	0.000625208
295001	0.000639049
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310001	0.000674393
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330001	0.000737563
335001	0.00081823
340001	0.000856715
345001	0.000737018
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355001	0.00135471
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365001	0.001119
370001	0.00113662
375001	0.0011993
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385001	0.00127384
390001	0.00123833
395001	0.00123346
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405001	0.00124616
410001	0.00128398
415001	0.00128159
420001	0.00131595
425001	0.00135981
430001	0.00132351
435001	0.0013351
440001	0.00137901
445001	0.00139873
450001	0.00132308
455001	0.00134034
460001	0.00143829
465001	0.0013664
470001	0.00138172
475001	0.00145137
480001	0.0014284
485001	0.00149353
490001	0.00150792
495001	0.00149775
500001	0.00106973
505001	0.0010926
510001	0.00120486
515001	0.00111586
520001	0.00111548
525001	0.00112312
530001	0.00115674
535001	0.00118471
540001	0.00112244
545001	0.0011931
550001	0.00124476
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560001	0.0012001
565001	0.00153581

570001	0.00123661
575001	0.00125888
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585001	0.00130891
590001	0.0013715
595001	0.00127158
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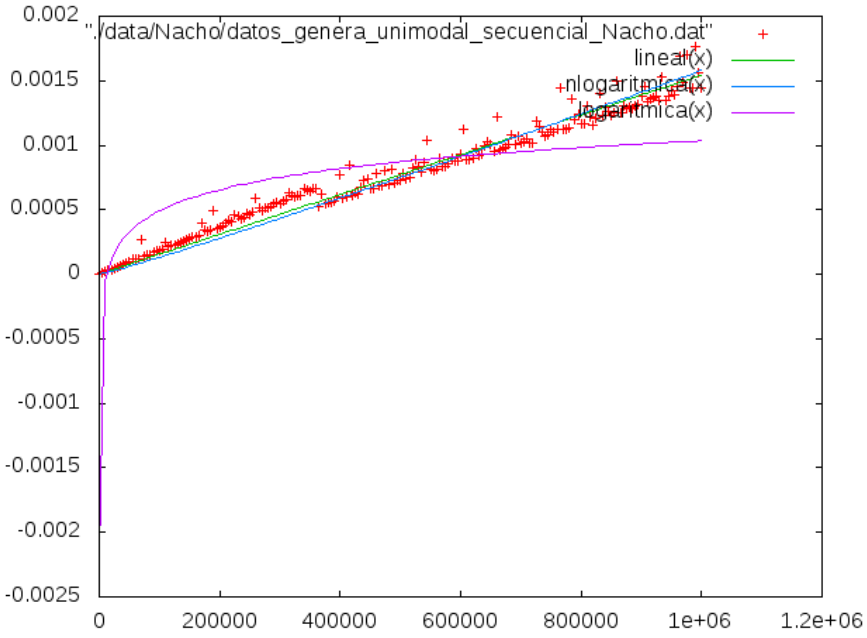
615001	0.00136257
620001	0.00133047
625001	0.00157993
630001	0.00160256
635001	0.00224412
640001	0.00227042
645001	0.00264473
650001	0.00139233
655001	0.00141823
660001	0.00151978
665001	0.00269443
670001	0.00198452
675001	0.00232555
680001	0.00278734
685001	0.0021844
690001	0.00206358
695001	0.00203935
700001	0.00210445
705001	0.00213257
710001	0.0020844
715001	0.00258757
720001	0.00153732
725001	0.00163313
730001	0.00155058
735001	0.00245493
740001	0.00157173
745001	0.00164656
750001	0.00156051

755001	0.00297318
760001	0.00362019
765001	0.00415503
770001	0.00172869
775001	0.00177365
780001	0.00166782
785001	0.00171216
790001	0.0018537
795001	0.00244351
800001	0.00455048
805001	0.00419158
810001	0.00389429
815001	0.0041388
820001	0.00363567
825001	0.00179199
830001	0.00182496
835001	0.00328139
840001	0.00332854
845001	0.00205908
850001	0.00182589
855001	0.00177933
860001	0.00185662
865001	0.00441101
870001	0.00201723
875001	0.0019275
880001	0.00185379
885001	0.00225509
890001	0.00196903
895001	0.00190935
900001	0.00193913
905001	0.00193483
910001	0.00194731
915001	0.00293374
920001	0.00469932
925001	0.00192188
930001	0.00201045
935001	0.00224927

940001	0.00204386
945001	0.00213312
950001	0.00332134
955001	0.00205959
960001	0.00328309
965001	0.00209894
970001	0.00223038
975001	0.00210922
980001	0.00221177
985001	0.00331399
990001	0.00222124
995001	0.00212957
1000001	0.00221753



-**Tabla y gŕafica de Luis(Fujitsu,Linux):**

Tamaño	Tiempo
1	1.65e-07
5001	8,93E-003
10001	1,42E-002
15001	2.2072e-05

20001	2,93E-002
25001	7.3206e-05
30001	4.3995e-05
35001	8.1913e-05
40001	5.8538e-05
45001	0.000131739
50001	7.3047e-05
55001	0.000109569
60001	8.7776e-05
65001	9.5069e-05
70001	0.000102334
75001	0.000109621
80001	0.000166209
85001	0.000149099
90001	0.000168333
95001	0.000231621
100001	0.000153719
105001	0.000159431
110001	0.000210312
115001	0.000176271
120001	0.000198383
125001	0.000240096

130001	0.000190838
135001	0.000212365
140001	0.000244785
145001	0.000213011
150001	0.000228014
155001	0.000234689
160001	0.000248774
165001	0.000280106
170001	0.000296496
175001	0.000258078
180001	0.000264963
185001	0.000262612
190001	0.00026995
195001	0.000356971
200001	0.000294089
205001	0.000301725
210001	0.000308938
215001	0.000315664
220001	0.00034824
225001	0.0003289
230001	0.000354303

235001	0.000654191
240001	0.000627257
245001	0.000615984
250001	0.000628281
255001	0.000673397
260001	0.000729668
265001	0.000966332
270001	0.00131237
275001	0.00117727
280001	0.000782564
285001	0.0007658
290001	0.000808406
295001	0.000836961
300001	0.000780479
305001	0.000950285
310001	0.000810363
315001	0.000792879
320001	0.00095634
325001	0.000883486
330001	0.000941352
335001	0.000935697

340001	0.000883123
345001	0.00092245
350001	0.000982877
355001	0.00089432
360001	0.00100362
365001	0.000950843
370001	0.000961586
375001	0.000943435
380001	0.000982561
385001	0.000997226
390001	0.00103753
395001	0.00119681
400001	0.00110818
405001	0.00104414
410001	0.00106905
415001	0.00125756
420001	0.00108333
425001	0.00110324
430001	0.00112414
435001	0.00117496
440001	0.00117137

445001	0.00111849
450001	0.00113079
455001	0.00123885
460001	0.00120047
465001	0.0011865
470001	0.00124812
475001	0.00152137
480001	0.00129417
485001	0.00125638
490001	0.0012734
495001	0.00133921
500001	0.0012837
505001	0.00128129
510001	0.00135213
515001	0.00133157
520001	0.00137378
525001	0.00135834
530001	0.0014917
535001	0.00140768
540001	0.00146108
545001	0.0014126

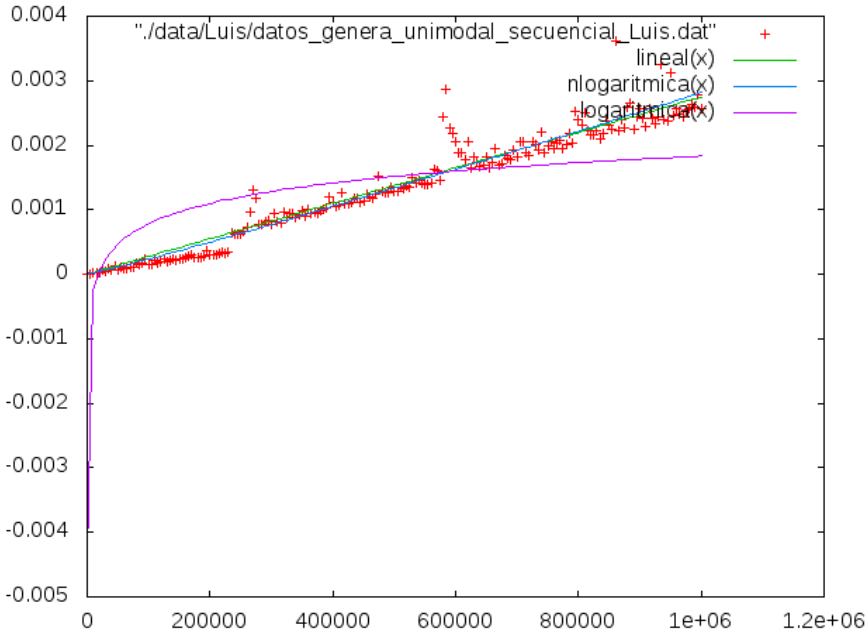
550001	0.00138364
555001	0.00139476
560001	0.00140883
565001	0.00162786
570001	0.00159838
575001	0.0014476
580001	0.00244171
585001	0.00286447
590001	0.00227871
595001	0.00217518
600001	0.00204661
605001	0.00188058
610001	0.00187855
615001	0.00177752
620001	0.00205222
625001	0.00165675
630001	0.00180923
635001	0.00173059
640001	0.00166831
645001	0.00169786
650001	0.00182026

655001	0.00164627
660001	0.00172811
665001	0.00194293
670001	0.00169218
675001	0.00171823
680001	0.0018487
685001	0.00179305
690001	0.00177858
695001	0.00192259
700001	0.00182309
705001	0.00205372
710001	0.00204714
715001	0.00188209
720001	0.00183284
725001	0.00206286
730001	0.0020021
735001	0.00191744
740001	0.00221491
745001	0.00187354
750001	0.00198633
755001	0.00205921

760001	0.00195037
765001	0.00202878
770001	0.00206821
775001	0.00194542
780001	0.00200215
785001	0.00219116
790001	0.00202818
795001	0.00252695
800001	0.00239506
805001	0.00230549
810001	0.00251272
815001	0.0022299
820001	0.00215939
825001	0.00215938
830001	0.00222084
835001	0.00210033
840001	0.00217242
845001	0.00237756
850001	0.00231043
855001	0.00225258
860001	0.00361198

865001	0.002218
870001	0.00239355
875001	0.00226665
880001	0.0025828
885001	0.00265594
890001	0.00225736
895001	0.00243189
900001	0.00257167
905001	0.00241975
910001	0.00229155
915001	0.00256359
920001	0.00240987
925001	0.00233638
930001	0.00242957
935001	0.00324645
940001	0.00239077
945001	0.00237946
950001	0.00312879
955001	0.00246237
960001	0.0025721
965001	0.00248514

970001	0.00244678
975001	0.00254417
980001	0.00256283
985001	0.00263438
990001	0.00259345
995001	0.00278291
1000001	0.00255994



-**Tabla y gŕafica de Miguel(Toshiba,Windows):**

Tamaño	Tiempo
1	0
5001	2.0955e-005
10001	4.14824e-005
15001	6.20098e-005
20001	8.21096e-005
25001	7.22735e-005

30001	8.63861e-005
35001	0.000100926
40001	0.000115039
45001	0.00013129
50001	0.000144547
55001	0.000158232
60001	0.0001732
65001	0.000188168
70001	0.000202708
75001	0.000216821
80001	0.000230505
85001	0.000244618
90001	0.000260441
95001	0.000273699
100001	0.000289522
105001	0.000308766
110001	0.000328438
115001	0.000379329
120001	0.00041012
125001	0.000360085
130001	0.000374197
135001	0.000388737
140001	0.000404133
145001	0.00041739
150001	0.000431503
155001	0.000449037
160001	0.000461011
165001	0.000475124
170001	0.00049223
175001	0.00050677
180001	0.000608552
185001	0.000611545
190001	0.000546969
195001	0.000561082
200001	0.000579044
205001	0.000591018
210001	0.000629934

215001	0.000618388
220001	0.000637204
225001	0.000649179
230001	0.000663719
235001	0.000715037
240001	0.000715893
245001	0.00095153
250001	0.000719742
255001	0.000735565
260001	0.000748394
265001	0.000764645
270001	0.00077662
275001	0.000791588
280001	0.000807411
285001	0.000847183
290001	0.000976334
295001	0.000849748
300001	0.000916462
305001	0.000886527
310001	0.000894652
315001	0.000912186
320001	0.000928864
325001	0.000942977
330001	0.00106272
335001	0.000963932
340001	0.000988308
345001	0.00102637
350001	0.00100798
355001	0.0010315
360001	0.00103749
365001	0.00125174
370001	0.00106785
375001	0.00109565
380001	0.00109351
385001	0.00110976
390001	0.00112687
395001	0.00115167

400001	0.00115467
405001	0.00123164
410001	0.00121924
415001	0.00119786
420001	0.00121283
425001	0.00134925
430001	0.00124191
435001	0.00127612
440001	0.00128125
445001	0.00132701
450001	0.00129451
455001	0.00139928
460001	0.00141639
465001	0.00135566
470001	0.00135994
475001	0.00138432
480001	0.00138517
485001	0.00140185
490001	0.00143264
495001	0.00146899
500001	0.00144462
505001	0.00147412
510001	0.00160883
515001	0.00150534
520001	0.00150449
525001	0.00151561
530001	0.0015464
535001	0.00161824
540001	0.00156136
545001	0.00162295
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555001	0.00159943
560001	0.00188039
565001	0.00188382
570001	0.0019052
575001	0.00208952
580001	0.00167427

585001	0.00169351
590001	0.00173371
595001	0.0017196
600001	0.00177647
605001	0.00182608
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615001	0.00179829
620001	0.0021464
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630001	0.00195096
635001	0.00183506
640001	0.00224818
645001	0.0018697
650001	0.0018774
655001	0.00189622
660001	0.00193428
665001	0.00195566
670001	0.00194412
675001	0.00197833
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685001	0.00205146
690001	0.00214554
695001	0.0020459
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705001	0.00210449
710001	0.00205787
715001	0.0021558
720001	0.00208481
725001	0.00237605
730001	0.00212287
735001	0.00216222
740001	0.00221268
745001	0.00216393
750001	0.00223663
755001	0.00218959
760001	0.0025702
765001	0.00225288

770001	0.00224091
775001	0.00225203
780001	0.00226186
785001	0.00243335
790001	0.00228966
795001	0.00239401
800001	0.00253128
805001	0.00233927
810001	0.0023444
815001	0.00239999
820001	0.00238161
825001	0.00244661
830001	0.0024094
835001	0.00242565
840001	0.00280284
845001	0.00246371
850001	0.00246927
855001	0.00271175
860001	0.00254198
865001	0.0025176
870001	0.00257106
875001	0.00254411
880001	0.00255309
885001	0.00273399
890001	0.00259201
895001	0.00259201
900001	0.00261468
905001	0.00263905
910001	0.00272544
915001	0.00278531
920001	0.00275495
925001	0.00268481
930001	0.00323349
935001	0.00271945
940001	0.00273314
945001	0.00274853
950001	0.00281952

955001	0.00300726
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970001	0.00282936
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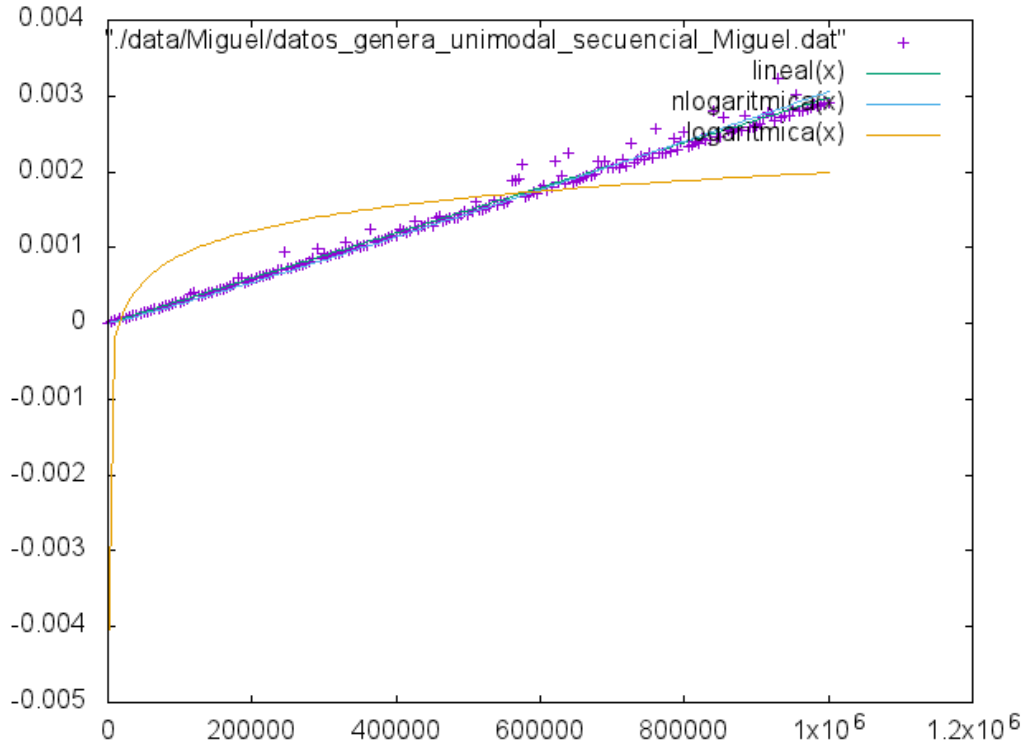
980001	0.00288153
985001	0.00286656
990001	0.00288196
995001	0.00290634
1000001	0.00290078



-**<u>Tabla y gráfica de Diego(MacBook Pro,MacOS El Capitán):</u>**

Tamaño	Tiempo
1	1.46e-07
5001	3,36E-003
10001	8,49E-003
15001	9,62E-003
20001	1,55E-002
25001	1.5962e-05
30001	1.9068e-05
35001	2.2213e-05

40001	2.5339e-05
45001	2,87E-002
50001	3.1768e-05
55001	4,70E-002
60001	3.7973e-05
65001	4.1143e-05
70001	5,07E-002
75001	4.7415e-05
80001	5.0665e-05
85001	5.3868e-05
90001	5.6742e-05
95001	6.0481e-05
100001	6,32E-002
105001	6.6451e-05
110001	7.0348e-05
115001	8.8778e-05
120001	7.6379e-05
125001	9.0963e-05
130001	9.1459e-05
135001	0.000107813
140001	9.1485e-05
145001	9.2429e-05
150001	9,54E-002
155001	9,82E-002
160001	0.000104178
165001	0.000105868
170001	0.000110005
175001	0.000134818
180001	0.000120587
185001	0.000117758
190001	0.000120811
195001	0.000128354
200001	0.000126392
205001	0.000126681
210001	0.000133319
215001	0.000160284
220001	0.00013935

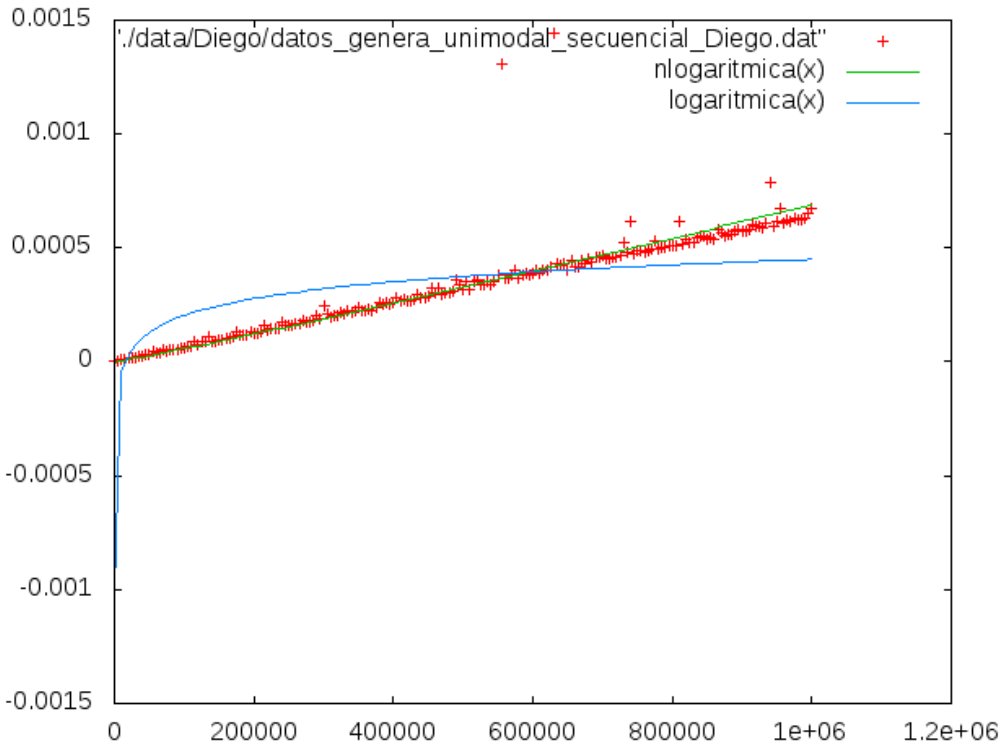
225001	0.000145601
230001	0.000145432
235001	0.000148843
240001	0.00017237
245001	0.000163304
250001	0.000158448
255001	0.000161332
260001	0.000165799
265001	0.000167015
270001	0.000180577
275001	0.000174203
280001	0.000177898
285001	0.000181299
290001	0.000203045
295001	0.000189335
300001	0.000243855
305001	0.000209938
310001	0.000197697
315001	0.00020097
320001	0.000201959
325001	0.000217791
330001	0.000209303
335001	0.000226739
340001	0.00021565
345001	0.000227974
350001	0.000236384
355001	0.000224983
360001	0.000227792
365001	0.000231807
370001	0.000222246
375001	0.000239658
380001	0.000261648
385001	0.000255104
390001	0.00025941
395001	0.000249444
400001	0.000260502
405001	0.000278876

410001	0.000270764
415001	0.000273193
420001	0.000267023
425001	0.000268917
430001	0.000271674
435001	0.00029611
440001	0.000279738
445001	0.000282297
450001	0.000287967
455001	0.000323654
460001	0.000301068
465001	0.000320741
470001	0.000296488
475001	0.000301187
480001	0.000303277
485001	0.000308092
490001	0.000360423
495001	0.000338067
500001	0.000316215
505001	0.000351308
510001	0.000317327
515001	0.000354469
520001	0.000360321
525001	0.000337517
530001	0.000337848
535001	0.000356139
540001	0.000340637
545001	0.000351936
550001	0.000381576
555001	0.00131066
560001	0.00036644
565001	0.000366209
570001	0.000378712
575001	0.00040349
580001	0.000367093
585001	0.000384168
590001	0.000390739

595001	0.000380573
600001	0.000385717
605001	0.000400861
610001	0.000388419
615001	0.000403319
620001	0.000405218
625001	0.000417977
630001	0.00144584
635001	0.000432179
640001	0.000422046
645001	0.000433095
650001	0.000400294
655001	0.000447429
660001	0.000416906
665001	0.000420302
670001	0.000444847
675001	0.000433178
680001	0.000453603
685001	0.000436862
690001	0.000458462
695001	0.000457254
700001	0.000468636
705001	0.000449562
710001	0.000449301
715001	0.000460481
720001	0.000459029
725001	0.00047007
730001	0.000526514
735001	0.000483886
740001	0.000614908
745001	0.000475854
750001	0.000486656
755001	0.000488968
760001	0.000480878
765001	0.000490991
770001	0.000494276
775001	0.000528421

780001	0.000495862
785001	0.000500321
790001	0.000502949
795001	0.000509235
800001	0.000511808
805001	0.000512701
810001	0.000618346
815001	0.000515731
820001	0.000535681
825001	0.00052634
830001	0.000525296
835001	0.000546462
840001	0.000548839
845001	0.000553154
850001	0.000536715
855001	0.000545815
860001	0.000540395
865001	0.000578994
870001	0.000566133
875001	0.000554675
880001	0.000561063
885001	0.000559228
890001	0.000570502
895001	0.000580354
900001	0.000571243
905001	0.000572548
910001	0.000577582
915001	0.000602889
920001	0.000596908
925001	0.000595489
930001	0.000591235
935001	0.000605916
940001	0.000790384
945001	0.000597289
950001	0.00061543
955001	0.000671175
960001	0.000611545

965001	0.000627043
970001	0.000617976
975001	0.000631645
980001	0.000621345
985001	0.000625939
990001	0.000632142
995001	0.000655101
1000001	0.000671709



1.2 Primera Solución DyV

En esta primera solución en la que empleamos DyV. Comenzamos presentando el código:

```
#include <iostream>
#include <vector>
#include <cstdlib>
#include <cstdio>
#include <ctime>
#include <climits>
#include <cassert>
#include <chrono>

using namespace std;
```

```
int& buscaPuntoDeCambio(int* v, int indice1, int indice2, int& res)
{
  int indi=(indice1+indice2)/2;
  if(v[indice1]>v[indice1+1])
  {
    res=indice1;
    return res;
  }
  else if(v[indice2]>v[indice2-1])
  {
    res=indice2;
    return res;
  }
  else if(v[indi]-v[indi-1]>0 &&  v[indi]-v[indi+1]>0)
  {
    res=indi;
    return res;
  }
  else
  {
    buscaPuntoDeCambio(v, indice1, indi, res);
    buscaPuntoDeCambio(v, indi, indice2, res);
  }

}

double uniforme()
{
double u;
  u = (double) rand();
  u = u/(double)(RAND_MAX+1.0);
 return u;
}


using namespace std::chrono;

int main(int argc, char* argv[])
{
  high_resolution_clock::time_point t1, t2;
  if(argc<2)
  {
    cout << "Falta el numero de componentes.\n";
    exit(1);
  }
  int n = atoi(argv[1]);

  int * T = new int[n];
  assert(T);

  srand(time(0));
  double u=uniforme();
```

```
  int p=1+(int)((n-2)*u);
  T[p]=n-1;
  for (int i=0; i<p; i++) T[i]=i;
  for (int i=p+1; i<n; i++) T[i]=n-1-i+p;

  int res=0;
  t1=high_resolution_clock::now();
  buscaPuntoDeCambio(T,0,n-1, res);
  t2=high_resolution_clock::now();
  int punto_cambio=res;
  duration<double> transcurrido = duration_cast<duration<double> >(t2-t1);
  cout << n << " " << transcurrido.count() << "\n";

  return 0;
}
```

En esta implementación el método que seguimos para obtener el punto de cambio es:
1) Obtenemos el punto medio del vector.
2) Comprobamos si los extremos son el punto que andamos buscando. Si el extremo izquierdo fuera este punto entonces el vector decrecería a partir de dicho punto. Si el extremo derecho fuera el punto entonces el vector crecería hasta dicho extremo.
3) Comprobamos si el punto de cambio es el propio punto medio mediante la comprobación del elemento que antecede al punto medio y el elemento que precede al mismo.
4) Si ninguna de estas comprobaciones nos otorga el punto entonces llamamos recursivamente al algoritmo para una sola de las partes del vector. Si a la derecha del punto medio el vector sigue creciendo descartamos la parte izquierda, si a la izquierda del punto medio el vector decrece descartamos la parte derecha.

Vemos que la eficiencia de dicho algoritmo es logarítmica, lo cual es confirmado al ajustar la función a los datos obtenidos. Lo observamos en este caso con la suma al cuadrado de los residuos obtenida en los ajustes.
Lineal = 2.85144e-10
nlogarítmica = 3.7745e-10
logarítmica = 2.42327e-10

Datos:
-**Tabla y gŕafica de Nacho(Toshiba,Linux):**

Tamaño	Tiempo
10000	7.36e-07
20000	6.27e-07
30000	6.12e-07
40000	8.56e-07
50000	7.62e-07
60000	6.61e-07
70000	9.82e-07
80000	8.24e-07

90000	7.98e-07
100000	7.25e-07
110000	7.54e-07
120000	5.34e-07
130000	9.76e-07
140000	1,27E-003
150000	8.12e-07
160000	6.92e-07
170000	9.05e-07
180000	7.45e-07
190000	7.69e-07
200000	9.82e-07
210000	7.07e-07
220000	5,25E-003
230000	1,25E-003
240000	1,09E-003
250000	7.46e-07
260000	6.09e-07
270000	7.91e-07
280000	7.34e-07
290000	7,71E-003
300000	7.38e-07
310000	1,11E-003
320000	9.39e-07
330000	1,44E-003
340000	1,14E-003
350000	9.78e-07
360000	7,04E-003
370000	9.27e-07
380000	9.86e-07
390000	1,09E-003
400000	2,12E-003
410000	1,40E-003
420000	1,21E-003
430000	7.75e-07
440000	8.51e-07
450000	1,57E-003

460000	1,31E-003
470000	5,00E-006
480000	1,28E-003
490000	1.49e-06
500000	1,24E-003
510000	1,72E-003
520000	1.17e-06
530000	1,48E-003
540000	1,80E-003
550000	1,58E-003
560000	1,20E-003
570000	1,64E-003
580000	1,55E-003
590000	1,33E-003
600000	1,89E-003
610000	1,67E-003
620000	1,66E-003
630000	1,49E-003
640000	2,04E-003
650000	1,24E-003
660000	2,00E-003
670000	1,30E-003
680000	2,58E-003
690000	1,53E-003
700000	1,62E-003
710000	1.33e-06
720000	1,51E-003
730000	1,43E-003
740000	1,12E-003
750000	1,93E-003
760000	1.03e-06
770000	1,26E-003
780000	1,94E-003
790000	1,36E-003
800000	1,09E-003
810000	1,51E-003
820000	1,48E-003

830000	1,36E-003
840000	8.07e-07
850000	1,73E-003
860000	5,06E-003
870000	9.55e-07
880000	1,42E-003
890000	1,26E-003
900000	1,08E-003
910000	1,40E-003
920000	1,13E-003
930000	1,16E-003
940000	2.35e-06
950000	1,29E-003
960000	8.61e-07
970000	4,00E-003
980000	1,33E-003
990000	1,33E-003
1000000	9.71e-07
1010000	1,60E-003
1020000	1.58e-06
1030000	1,90E-003
1040000	1,61E-003
1050000	1,12E-003
1060000	4,15E-003
1070000	1,25E-003
1080000	1,39E-003
1090000	1,70E-003
1100000	8.77e-07
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1120000	2,05E-003
1130000	1,19E-003
1140000	9.06e-07
1150000	1,34E-003
1160000	1,38E-003
1170000	1,59E-003
1180000	1,29E-003
1190000	8.55e-07

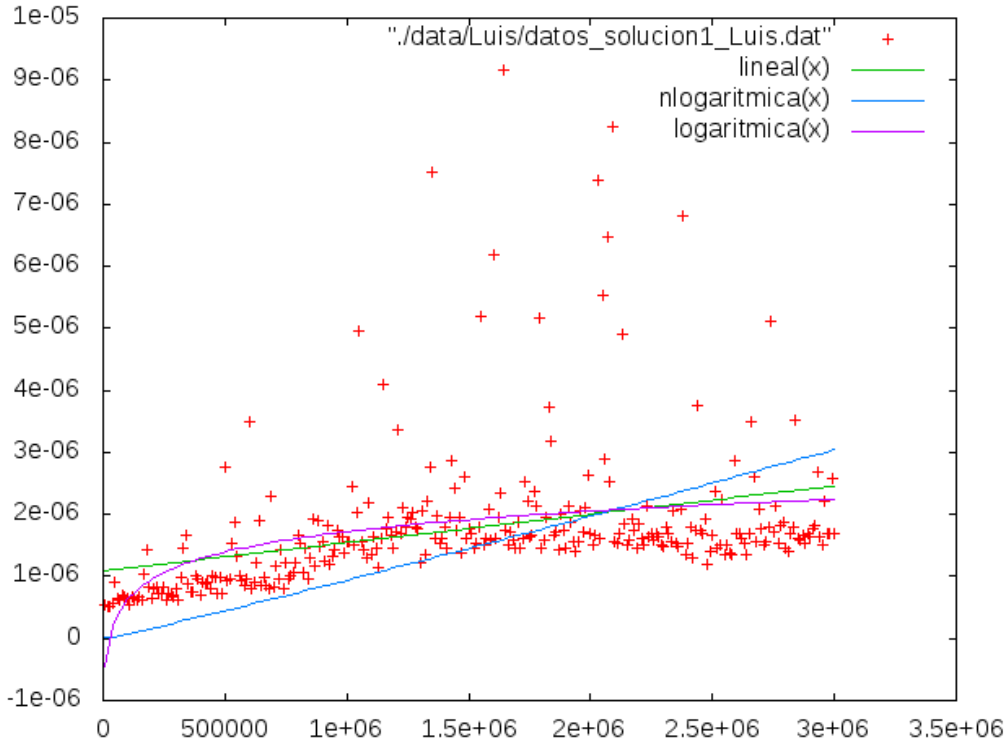
1200000	1,05E-003
1210000	1.06e-06
1220000	1,07E-003
1230000	9.1e-07
1240000	1,19E-003
1250000	8.73e-07
1260000	9.25e-07
1270000	1,61E-003
1280000	1,23E-003
1290000	1,87E-003
1300000	1,32E-003
1310000	1,12E-003
1320000	1,16E-003
1330000	1,43E-003
1340000	1,69E-003
1350000	1,56E-003
1360000	1.45e-06
1370000	1,29E-003
1380000	1,08E-003
1390000	1,23E-003
1400000	8.36e-07
1410000	9.96e-07
1420000	1,34E-003
1430000	1,21E-003
1440000	1,10E-003
1450000	1,01E-003
1460000	1,31E-003
1470000	1,20E-003
1480000	1,09E-003
1490000	2.41e-06
1500000	1,91E-003
1510000	2,09E-003
1520000	1.7e-06
1530000	1,44E-003
1540000	1,11E-003
1550000	1,18E-003
1560000	9.82e-07

1570000	3,18E-003
1580000	8.8e-07
1590000	9.01e-07
1600000	1,36E-003
1610000	1,24E-003
1620000	3,42E-003
1630000	1,26E-003
1640000	1,16E-003
1650000	1,04E-003
1660000	1,16E-003
1670000	1,06E-003
1680000	1,41E-003
1690000	1,99E-003
1700000	1,08E-003
1710000	1,06E-003
1720000	1,61E-003
1730000	1,70E-003
1740000	1,46E-003
1750000	1,33E-003
1760000	1,72E-003
1770000	1,43E-003
1780000	1,48E-003
1790000	1,59E-003
1800000	1,17E-003
1810000	2,18E-003
1820000	1,03E-003
1830000	9.69e-07
1840000	9.58e-07
1850000	1,15E-003
1860000	2,10E-003
1870000	8.73e-07
1880000	2,18E-003
1890000	1,99E-003
1900000	1,28E-003
1910000	1,37E-003
1920000	1,16E-003
1930000	1.74e-06

1940000	1,04E-003
1950000	2,90E-003
1960000	1,05E-003
1970000	1,59E-003
1980000	1,58E-003
1990000	1,47E-003
2000000	1,43E-003
2010000	1.52e-06
2020000	2,39E-003
2030000	1,39E-003
2040000	2,14E-003
2050000	1,30E-003
2060000	1,58E-003
2070000	3,51E-003
2080000	1,23E-003
2090000	1,84E-003
2100000	2,21E-003
2110000	1,38E-003
2120000	1,40E-003
2130000	2,07E-003
2140000	2,19E-003
2150000	1,36E-003
2160000	1,81E-003
2170000	1,49E-003
2180000	1,31E-003
2190000	1.98e-06
2200000	1,26E-003
2210000	1,87E-003
2220000	1,17E-003
2230000	1,31E-003
2240000	1,11E-003
2250000	1.77e-06
2260000	2,18E-003
2270000	1,90E-003
2280000	2,18E-003
2290000	1,02E-003
2300000	2,27E-003

2310000	9.21e-07
2320000	1,43E-003
2330000	1,36E-003
2340000	2,03E-003
2350000	1,83E-003
2360000	2.57e-06
2370000	3,33E-003
2380000	3,09E-003
2390000	1,43E-003
2400000	4,36E-003
2410000	1,80E-003
2420000	3,48E-003
2430000	2,19E-003
2440000	1,71E-003
2450000	1,66E-003
2460000	1,38E-003
2470000	2,60E-003
2480000	2,01E-003
2490000	2,37E-003
2500000	1,42E-003
2510000	2,23E-003
2520000	1,54E-003
2530000	1,37E-003
2540000	2,45E-003
2550000	1,52E-003
2560000	2,13E-003
2570000	1,32E-003
2580000	2.7e-06
2590000	1,63E-003
2600000	1,51E-003
2610000	2,06E-003
2620000	1,79E-003
2630000	2,74E-003
2640000	1.69e-06
2650000	1,47E-003
2660000	1,71E-003
2670000	1.98e-06

2680000	2,02E-003
2690000	1,51E-003
2700000	1,84E-003
2710000	2,34E-003
2720000	1,70E-003
2730000	1,48E-003
2740000	2,22E-003
2750000	1,64E-003
2760000	1,30E-003
2770000	2,37E-003
2780000	5.36e-06
2790000	1,35E-003
2800000	1,42E-003
2810000	1.1669e-05
2820000	1,83E-003
2830000	1,58E-003
2840000	1.0257e-05
2850000	1.56e-06
2860000	2,38E-003
2870000	2,04E-003
2880000	1,46E-003
2890000	7.07e-06
2900000	1,39E-003
2910000	1,65E-003
2920000	1,38E-003
2930000	1,39E-003
2940000	1,99E-003
2950000	1,91E-003
2960000	1,69E-003
2970000	1,60E-003
2980000	1,72E-003
2990000	1,70E-003



-<u>Tabla y gráfica de Luis(Fujitsu,Linux):</u>

Tamaño	Tiempo
10001	5.38e-07
20001	5.25e-07
30001	5.15e-07
40001	5.7e-07
50001	9.15e-07
60001	6.54e-07
70001	6.3e-07
80001	6.95e-07
90001	6.68e-07
100001	6.39e-07
110001	5.31e-07
120001	6.83e-07
130001	6.41e-07
140001	6.17e-07
150001	6.83e-07
160001	6.19e-07
170001	1,04E-03

180001	1,42E-03
190001	8.2e-07
200001	6.57e-07
210001	8.14e-07
220001	8.35e-07
230001	7.37e-07
240001	7.21e-07
250001	8.33e-07
260001	6.32e-07
270001	7.13e-07
280001	7.09e-07
290001	6.61e-07
300001	7.95e-07
310001	6.32e-07
320001	9.93e-07
330001	1.46e-06
340001	1,66E-03
350001	8.88e-07
360001	7.42e-07
370001	7.39e-07
380001	1,01E-03
390001	9.49e-07
400001	7.05e-07
410001	9.08e-07
420001	8.92e-07
430001	9.02e-07
440001	8.09e-07
450001	1,01E-03
460001	9.88e-07
470001	7.19e-07
480001	9.75e-07
490001	7.25e-07
500001	2,76E-03
510001	9.36e-07
520001	9.53e-07
530001	1,55E-03
540001	1,89E-03

550001	1,33E-03
560001	1,02E-03
570001	9.29e-07
580001	8.6e-07
590001	9.59e-07
600001	3,50E-03
610001	8.07e-07
620001	8.96e-07
630001	1,23E-03
640001	1.9e-06
650001	8.56e-07
660001	9.9e-07
670001	8.56e-07
680001	7.94e-07
690001	2,29E-03
700001	8.4e-07
710001	1.16e-06
720001	9.58e-07
730001	1,44E-03
740001	8.1e-07
750001	1,21E-03
760001	9.53e-07
770001	1,02E-03
780001	1,05E-03
790001	1,21E-03
800001	1.66e-06
810001	1,54E-03
820001	1,07E-03
830001	1,46E-03
840001	9.5e-07
850001	1,30E-03
860001	1,93E-03
870001	1,18E-03
880001	1,91E-03
890001	1,49E-03
900001	1,55E-03
910001	1,25E-03

920001	1,81E-03
930001	1,20E-03
940001	1,32E-03
950001	1,43E-03
960001	1,74E-03
970001	1,63E-03
980001	1,63E-03
990001	1.39e-06
1000001	1,56E-03
1010001	1,57E-03
1020001	2,45E-03
1030001	1,51E-03
1040001	2,02E-03
1050001	4,97E-03
1060001	1,56E-03
1070001	1,44E-03
1080001	1.29e-06
1090001	2,19E-03
1100001	1,36E-03
1110001	1,63E-03
1120001	1,45E-03
1130001	1,14E-03
1140001	1,61E-03
1150001	4,09E-03
1160001	1,76E-03
1170001	1,95E-03
1180001	1,67E-03
1190001	1,44E-03
1200001	1,71E-03
1210001	3,36E-03
1220001	1,69E-03
1230001	2,11E-03
1240001	1,81E-03
1250001	1.94e-06
1260001	1,94E-03
1270001	2.02e-06
1280001	1,79E-03

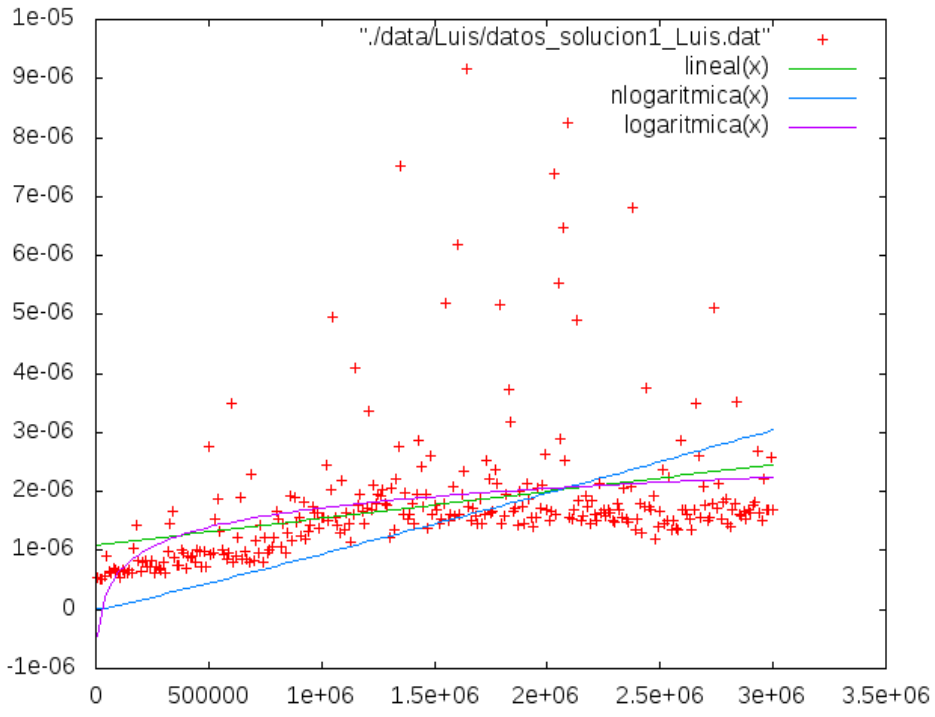
1290001	1,77E-03
1300001	1,23E-03
1310001	2,04E-03
1320001	1,36E-03
1330001	2,23E-03
1340001	2,75E-03
1350001	7,52E-03
1360001	1,60E-03
1370001	1,97E-03
1380001	1,54E-03
1390001	1.61e-06
1400001	1.79e-06
1410001	1,45E-03
1420001	1,95E-03
1430001	2,87E-03
1440001	2.43e-06
1450001	1,74E-03
1460001	1,96E-03
1470001	1,39E-03
1480001	2,62E-03
1490001	1,61E-03
1500001	1,76E-03
1510001	1.68e-06
1520001	1,46E-03
1530001	1.53e-06
1540001	1,80E-03
1550001	5,20E-03
1560001	1,50E-03
1570001	1,62E-03
1580001	2.09e-06
1590001	1,59E-03
1600001	6,19E-03
1610001	1,62E-03
1620001	1.95e-06
1630001	2,35E-03
1640001	9,17E-03
1650001	1.75e-06

1660001	1,51E-03
1670001	1,73E-03
1680001	1,59E-03
1690001	1,45E-03
1700001	1,88E-03
1710001	1,45E-03
1720001	1,61E-03
1730001	2,52E-03
1740001	2,20E-03
1750001	1,63E-03
1760001	1,66E-03
1770001	2,36E-03
1780001	2,12E-03
1790001	5,18E-03
1800001	1,45E-03
1810001	1,59E-03
1820001	1,94E-03
1830001	3,72E-03
1840001	3,18E-03
1850001	1,67E-03
1860001	1,71E-03
1870001	1.44e-06
1880001	2,00E-03
1890001	1,74E-03
1900001	1,46E-03
1910001	2,15E-03
1920001	1,89E-03
1930001	1,57E-03
1940001	1,39E-03
1950001	1.56e-06
1960001	2.07e-06
1970001	1,73E-03
1980001	2.1e-06
1990001	2,63E-03
2000001	1,70E-03
2010001	1,50E-03
2020001	1,67E-03

2030001	7,38E-03
2040001	1,62E-03
2050001	5,55E-03
2060001	2,88E-03
2070001	6,47E-03
2080001	2,52E-03
2090001	8,26E-03
2100001	1,57E-03
2110001	1.53e-06
2120001	1,69E-03
2130001	4,91E-03
2140001	1,84E-03
2150001	1,50E-03
2160001	1,59E-03
2170001	1,93E-03
2180001	1,75E-03
2190001	1,46E-03
2200001	1,86E-03
2210001	1,62E-03
2220001	1.51e-06
2230001	2,13E-03
2240001	1.63e-06
2250001	1,70E-03
2260001	1,59E-03
2270001	1,69E-03
2280001	1,63E-03
2290001	1,51E-03
2300001	1,47E-03
2310001	1,81E-03
2320001	1,69E-03
2330001	1,56E-03
2340001	2,05E-03
2350001	1,55E-03
2360001	1,49E-03
2370001	2.08e-06
2380001	6,82E-03
2390001	1.36e-06

2400001	1,53E-03
2410001	1,81E-03
2420001	1,30E-03
2430001	1,75E-03
2440001	3,76E-03
2450001	1,74E-03
2460001	1,70E-03
2470001	1,92E-03
2480001	1,20E-03
2490001	1,40E-03
2500001	1,68E-03
2510001	2,38E-03
2520001	1,46E-03
2530001	1,51E-03
2540001	2,23E-03
2550001	1,35E-03
2560001	1,51E-03
2570001	1,38E-03
2580001	1,34E-03
2590001	2,86E-03
2600001	1,70E-03
2610001	1,70E-03
2620001	1,62E-03
2630001	1,52E-03
2640001	1,35E-03
2650001	1,69E-03
2660001	3.5e-06
2670001	2,60E-03
2680001	1,57E-03
2690001	2,08E-03
2700001	1,78E-03
2710001	1,50E-03
2720001	1,57E-03
2730001	1,79E-03
2740001	5,12E-03
2750001	1,73E-03
2760001	2,14E-03

2770001	1,54E-03
2780001	1,82E-03
2790001	1,86E-03
2800001	1,47E-03
2810001	1.4e-06
2820001	1,70E-03
2830001	1,79E-03
2840001	3,52E-03
2850001	1,61E-03
2860001	1,58E-03
2870001	1,67E-03
2880001	1,53E-03
2890001	1,70E-03
2900001	1.63e-06
2910001	1,78E-03
2920001	1,82E-03
2930001	2.68e-06
2940001	1,63E-03
2950001	1,51E-03
2960001	2.22e-06
2970001	1.7e-06
2980001	1,68E-03
2990001	2,59E-03
3000001	1,69E-03



-**Tabla y gŕafica de Miguel(Toshiba,Windows):**

Tamaño	Tiempo
10001	4.27654e-007
20001	4.27654e-007
30001	4.27654e-007
40001	4.27654e-007
50001	8.55308e-007
60001	4.27654e-007
70001	8.55308e-007
80001	4.27654e-007
90001	8.55308e-007
100001	4.27654e-007
110001	4.27654e-007
120001	8.55308e-007
130001	4.27654e-007
140001	4.27654e-007
150001	4.27654e-007
160001	4.27654e-007
170001	4.27654e-007
180001	4.27654e-007
190001	8.55308e-007
200001	4.27654e-007
210001	8.55308e-007
220001	4.27654e-007
230001	4.27654e-007
240001	4.27654e-007
250001	4.27654e-007
260001	4.27654e-007
270001	4.27654e-007
280001	8.55308e-007
290001	4.27654e-007
300001	8.55308e-007
310001	8.55308e-007
320001	8.55308e-007
330001	8.55308e-007

340001	8.55308e-007
350001	8.55308e-007
360001	4.27654e-007
370001	8.55308e-007
380001	5.13185e-006
390001	8.55308e-007
400001	8.55308e-007
410001	8.55308e-007
420001	4.27654e-007
430001	8.55308e-007
440001	4.27654e-007
450001	8.55308e-007
460001	8.55308e-007
470001	8.55308e-007
480001	4.27654e-007
490001	8.55308e-007
500001	8.55308e-007
510001	8.55308e-007
520001	4.27654e-007
530001	8.55308e-007
540001	4.27654e-007
550001	8.55308e-007
560001	4.27654e-007
570001	8.55308e-007
580001	8.55308e-007
590001	8.55308e-007
600001	8.55308e-007
610001	4.27654e-007
620001	4.27654e-007
630001	4.27654e-007
640001	8.55308e-007
650001	8.55308e-007
660001	8.55308e-007
670001	8.55308e-007
680001	8.55308e-007
690001	1.28296e-006
700001	4.27654e-007

710001	8.55308e-007
720001	8.55308e-007
730001	4.27654e-007
740001	4.27654e-007
750001	8.55308e-007
760001	4.27654e-007
770001	8.55308e-007
780001	8.55308e-007
790001	4.27654e-007
800001	8.55308e-007
810001	8.55308e-007
820001	4.27654e-007
830001	4.27654e-007
840001	4.27654e-007
850001	1.28296e-006
860001	8.55308e-007
870001	8.55308e-007
880001	1.28296e-006
890001	8.55308e-007
900001	8.55308e-007
910001	4.27654e-007
920001	8.55308e-007
930001	8.55308e-007
940001	8.55308e-007
950001	4.27654e-007
960001	4.27654e-007
970001	4.27654e-007
980001	8.55308e-007
990001	8.55308e-007
1000001	8.55308e-007
1010001	8.55308e-007
1020001	8.55308e-007
1030001	4.27654e-007
1040001	8.55308e-007
1050001	4.27654e-007
1060001	8.55308e-007
1070001	8.55308e-007

1080001	4.27654e-007
1090001	1.71062e-006
1100001	8.55308e-007
1110001	4.27654e-007
1120001	8.55308e-007
1130001	4.27654e-007
1140001	3.42123e-006
1150001	8.55308e-007
1160001	8.55308e-007
1170001	8.55308e-007
1180001	1.28296e-006
1190001	8.55308e-007
1200001	8.55308e-007
1210001	8.55308e-007
1220001	1.28296e-006
1230001	4.27654e-007
1240001	8.55308e-007
1250001	1.28296e-006
1260001	4.27654e-007
1270001	8.55308e-007
1280001	8.55308e-007
1290001	8.55308e-007
1300001	8.55308e-007
1310001	8.55308e-007
1320001	8.55308e-007
1330001	8.55308e-007
1340001	8.55308e-007
1350001	8.55308e-007
1360001	8.55308e-007
1370001	8.55308e-007
1380001	8.55308e-007
1390001	4.27654e-007
1400001	8.55308e-007
1410001	8.55308e-007
1420001	8.55308e-007
1430001	8.55308e-007
1440001	8.55308e-007

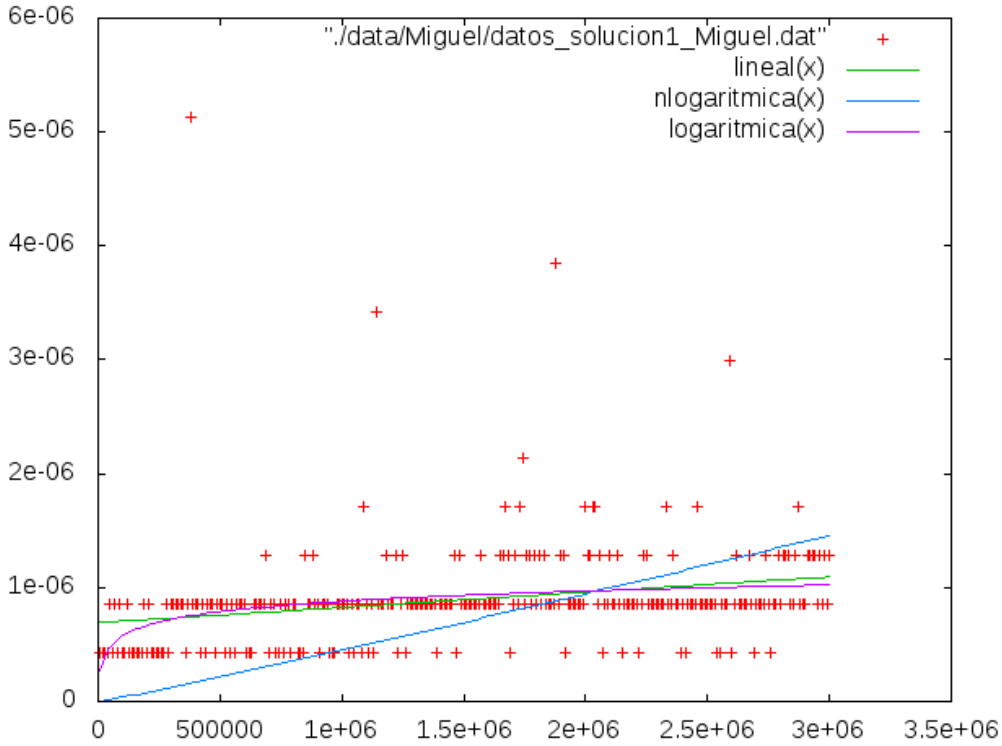
1450001	8.55308e-007
1460001	1.28296e-006
1470001	4.27654e-007
1480001	1.28296e-006
1490001	8.55308e-007
1500001	8.55308e-007
1510001	8.55308e-007
1520001	8.55308e-007
1530001	8.55308e-007
1540001	8.55308e-007
1550001	8.55308e-007
1560001	8.55308e-007
1570001	1.28296e-006
1580001	8.55308e-007
1590001	8.55308e-007
1600001	8.55308e-007
1610001	8.55308e-007
1620001	8.55308e-007
1630001	8.55308e-007
1640001	8.55308e-007
1650001	1.28296e-006
1660001	1.28296e-006
1670001	1.71062e-006
1680001	1.28296e-006
1690001	4.27654e-007
1700001	8.55308e-007
1710001	1.28296e-006
1720001	8.55308e-007
1730001	1.71062e-006
1740001	2.13827e-006
1750001	8.55308e-007
1760001	1.28296e-006
1770001	1.28296e-006
1780001	8.55308e-007
1790001	1.28296e-006
1800001	8.55308e-007
1810001	1.28296e-006

1820001	8.55308e-007
1830001	1.28296e-006
1840001	8.55308e-007
1850001	8.55308e-007
1860001	8.55308e-007
1870001	8.55308e-007
1880001	3.84889e-006
1890001	8.55308e-007
1900001	1.28296e-006
1910001	1.28296e-006
1920001	4.27654e-007
1930001	8.55308e-007
1940001	8.55308e-007
1950001	8.55308e-007
1960001	8.55308e-007
1970001	8.55308e-007
1980001	8.55308e-007
1990001	8.55308e-007
2000001	1.71062e-006
2010001	1.28296e-006
2020001	1.28296e-006
2030001	1.71062e-006
2040001	1.71062e-006
2050001	8.55308e-007
2060001	1.28296e-006
2070001	4.27654e-007
2080001	8.55308e-007
2090001	8.55308e-007
2100001	1.28296e-006
2110001	8.55308e-007
2120001	8.55308e-007
2130001	1.28296e-006
2140001	8.55308e-007
2150001	4.27654e-007
2160001	8.55308e-007
2170001	8.55308e-007
2180001	8.55308e-007

2190001	8.55308e-007
2200001	8.55308e-007
2210001	8.55308e-007
2220001	4.27654e-007
2230001	8.55308e-007
2240001	1.28296e-006
2250001	1.28296e-006
2260001	8.55308e-007
2270001	8.55308e-007
2280001	8.55308e-007
2290001	8.55308e-007
2300001	8.55308e-007
2310001	8.55308e-007
2320001	8.55308e-007
2330001	1.71062e-006
2340001	8.55308e-007
2350001	8.55308e-007
2360001	1.28296e-006
2370001	8.55308e-007
2380001	8.55308e-007
2390001	4.27654e-007
2400001	8.55308e-007
2410001	4.27654e-007
2420001	8.55308e-007
2430001	8.55308e-007
2440001	8.55308e-007
2450001	8.55308e-007
2460001	1.71062e-006
2470001	8.55308e-007
2480001	8.55308e-007
2490001	8.55308e-007
2500001	8.55308e-007
2510001	8.55308e-007
2520001	8.55308e-007
2530001	8.55308e-007
2540001	4.27654e-007
2550001	4.27654e-007

2560001	8.55308e-007
2570001	8.55308e-007
2580001	8.55308e-007
2590001	2.99358e-006
2600001	4.27654e-007
2610001	8.55308e-007
2620001	1.28296e-006
2630001	8.55308e-007
2640001	8.55308e-007
2650001	8.55308e-007
2660001	8.55308e-007
2670001	1.28296e-006
2680001	8.55308e-007
2690001	4.27654e-007
2700001	8.55308e-007
2710001	8.55308e-007
2720001	8.55308e-007
2730001	8.55308e-007
2740001	1.28296e-006
2750001	8.55308e-007
2760001	4.27654e-007
2770001	8.55308e-007
2780001	8.55308e-007
2790001	1.28296e-006
2800001	8.55308e-007
2810001	1.28296e-006
2820001	1.28296e-006
2830001	1.28296e-006
2840001	8.55308e-007
2850001	8.55308e-007
2860001	1.28296e-006
2870001	1.71062e-006
2880001	8.55308e-007
2890001	8.55308e-007
2900001	8.55308e-007
2910001	1.28296e-006
2920001	1.28296e-006

2930001	1.28296e-006
2940001	1.28296e-006
2950001	8.55308e-007
2960001	1.28296e-006
2970001	8.55308e-007
2980001	1.28296e-006
2990001	8.55308e-007
3000001	1.28296e-006



-**<u>Tabla y gráfica de Diego(MacBook Pro,MacOS El Capitán):</u>**

Tamaño	Tiempo
10001	6.32e-07
20001	8.81e-07
30001	1,03E-003
40001	9.8e-07
50001	7.97e-07
60001	8.5e-07
70001	8.73e-07
80001	9.93e-07
90001	7.97e-07
100001	7.32e-07
110001	9.24e-07

120001	1,05E-003
130001	2,04E-003
140001	6.74e-07
150001	7.88e-07
160001	7.73e-07
170001	7.93e-07
180001	7.54e-07
190001	7.2e-07
200001	7.85e-07
210001	7.48e-07
220001	9.95e-07
230001	7.35e-07
240001	8.44e-07
250001	9.41e-07
260001	7.51e-07
270001	1,00E-003
280001	7.06e-07
290001	1,36E-003
300001	8.46e-07
310001	8.52e-07
320001	8.57e-07
330001	1,43E-003
340001	9.36e-07
350001	1,02E-003
360001	1,08E-003
370001	1,04E-003
380001	8.15e-07
390001	7.89e-07
400001	9.87e-07
410001	2,32E-003
420001	1,18E-003
430001	1,08E-003
440001	9.72e-07
450001	9.13e-07
460001	9.78e-07
470001	1,36E-003
480001	1,10E-003

490001	7.99e-07
500001	2,65E-003
510001	1,40E-003
520001	9.56e-07
530001	1,88E-003
540001	1.18e-06
550001	9.22e-07
560001	1,25E-003
570001	1.0517e-05
580001	1,26E-003
590001	1,47E-003
600001	1,18E-003
610001	1,36E-003
620001	1.15e-06
630001	1,06E-003
640001	2.18e-06
650001	1,93E-003
660001	1.3e-06
670001	9.56e-07
680001	1,51E-003
690001	1,12E-003
700001	1,18E-003
710001	1,67E-003
720001	1.69e-06
730001	1,68E-003
740001	1,35E-003
750001	1,63E-003
760001	1,71E-003
770001	1,18E-003
780001	8.05e-07
790001	2,77E-003
800001	1.31e-06
810001	1,60E-003
820001	1,05E-003
830001	1,23E-003
840001	1,73E-003
850001	1,63E-003

860001	1,76E-003
870001	1,64E-003
880001	1,85E-003
890001	1,84E-003
900001	1,11E-003
910001	2,61E-003
920001	1,14E-003
930001	1.84e-06
940001	1.49e-06
950001	1,68E-003
960001	1.19e-06
970001	1,51E-003
980001	1,37E-003
990001	1,53E-003
1000001	1,87E-003
1010001	1,28E-003
1020001	1,64E-003
1030001	1,63E-003
1040001	1,74E-003
1050001	1,57E-003
1060001	1,85E-003
1070001	1,72E-003
1080001	2,13E-003
1090001	1,21E-003
1100001	1,25E-003
1110001	1,45E-003
1120001	2,70E-003
1130001	1,70E-003
1140001	1,28E-003
1150001	1,13E-003
1160001	1,24E-003
1170001	1,79E-003
1180001	1,53E-003
1190001	1.78e-06
1200001	1,78E-003
1210001	1.57e-06
1220001	1,66E-003

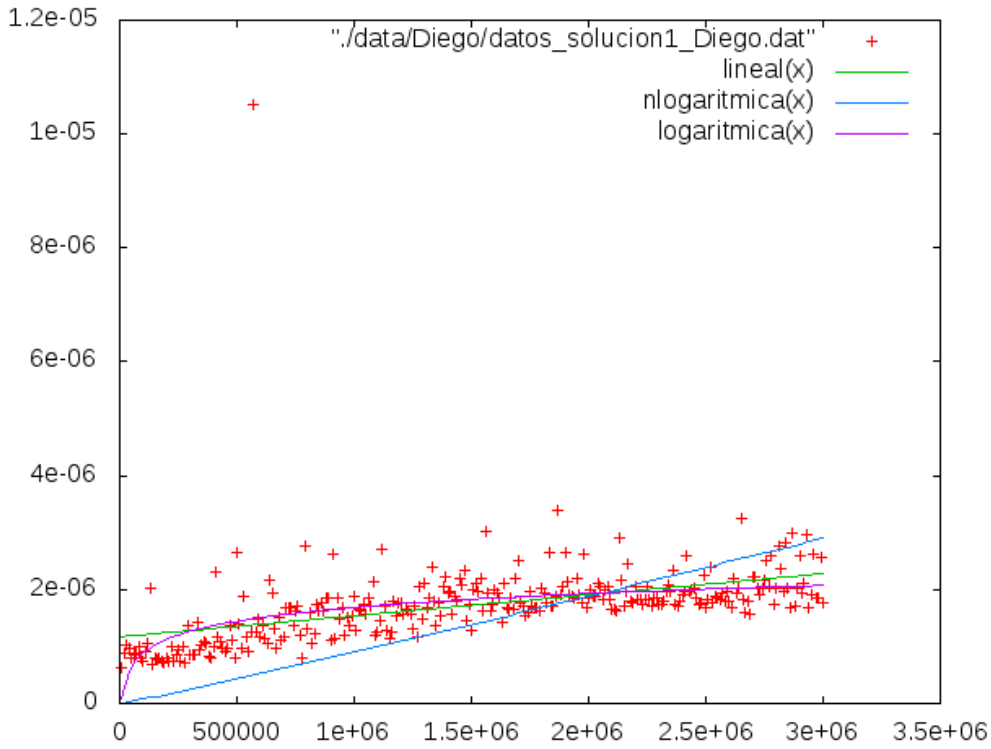
1230001	1,62E-003
1240001	1,56E-003
1250001	1,32E-003
1260001	1,71E-003
1270001	1,17E-003
1280001	2,06E-003
1290001	1,48E-003
1300001	2,10E-003
1310001	1,69E-003
1320001	1,86E-003
1330001	2,39E-003
1340001	1,79E-003
1350001	1,37E-003
1360001	1,77E-003
1370001	1,53E-003
1380001	2.06e-06
1390001	2,22E-003
1400001	1,94E-003
1410001	1,97E-003
1420001	1,56E-003
1430001	1,89E-003
1440001	1,81E-003
1450001	2,18E-003
1460001	2,08E-003
1470001	2,34E-003
1480001	1,46E-003
1490001	1,75E-003
1500001	1,29E-003
1510001	1,99E-003
1520001	2,11E-003
1530001	1,96E-003
1540001	2,20E-003
1550001	1,63E-003
1560001	3.02e-06
1570001	1.94e-06
1580001	1,63E-003
1590001	1,74E-003

1600001	2,01E-003
1610001	1,93E-003
1620001	1.84e-06
1630001	1,44E-003
1640001	2,10E-003
1650001	1,67E-003
1660001	1,64E-003
1670001	1,86E-003
1680001	1,66E-003
1690001	2.19e-06
1700001	2,51E-003
1710001	1,76E-003
1720001	1,71E-003
1730001	1,53E-003
1740001	1,60E-003
1750001	1,97E-003
1760001	1,70E-003
1770001	1,68E-003
1780001	1,69E-003
1790001	1,62E-003
1800001	2,04E-003
1810001	1,93E-003
1820001	1,76E-003
1830001	2,66E-003
1840001	1,72E-003
1850001	1,72E-003
1860001	1,88E-003
1870001	3,40E-003
1880001	1,92E-003
1890001	2,06E-003
1900001	2,65E-003
1910001	2,15E-003
1920001	1,91E-003
1930001	1,87E-003
1940001	1,85E-003
1950001	2,21E-003
1960001	1,92E-003

1970001	1,76E-003
1980001	2,62E-003
1990001	1,68E-003
2000001	1,85E-003
2010001	1,98E-003
2020001	1,89E-003
2030001	1,88E-003
2040001	2,12E-003
2050001	2,05E-003
2060001	1,81E-003
2070001	2,00E-003
2080001	2,04E-003
2090001	1,82E-003
2100001	1,66E-003
2110001	1,65E-003
2120001	1,61E-003
2130001	2,92E-003
2140001	2,17E-003
2150001	1,72E-003
2160001	1,97E-003
2170001	2,44E-003
2180001	1,79E-003
2190001	1,78E-003
2200001	2,04E-003
2210001	1,83E-003
2220001	1,84E-003
2230001	1,74E-003
2240001	1.81e-06
2250001	2,05E-003
2260001	1,82E-003
2270001	1,72E-003
2280001	1,85E-003
2290001	1,84E-003
2300001	1,73E-003
2310001	1.73e-06
2320001	1,79E-003
2330001	1,97E-003

2340001	2,08E-003
2350001	1,97E-003
2360001	2,35E-003
2370001	1,75E-003
2380001	1,72E-003
2390001	1,80E-003
2400001	1,92E-003
2410001	1,95E-003
2420001	2,59E-003
2430001	1,97E-003
2440001	1,99E-003
2450001	2,03E-003
2460001	1,85E-003
2470001	1.75e-06
2480001	1,77E-003
2490001	2,26E-003
2500001	1,70E-003
2510001	1,83E-003
2520001	2,40E-003
2530001	1,76E-003
2540001	1,87E-003
2550001	1,86E-003
2560001	1.82e-06
2570001	1,95E-003
2580001	1,78E-003
2590001	1,96E-003
2600001	1,80E-003
2610001	1,69E-003
2620001	2,19E-003
2630001	1,95E-003
2640001	2,03E-003
2650001	3,25E-003
2660001	1,83E-003
2670001	1,61E-003
2680001	1,79E-003
2690001	1,57E-003
2700001	2,23E-003

2710001	2,24E-003
2720001	2,02E-003
2730001	1,90E-003
2740001	2,03E-003
2750001	2,15E-003
2760001	2,51E-003
2770001	2,06E-003
2780001	2,59E-003
2790001	1,75E-003
2800001	2.02e-06
2810001	2,76E-003
2820001	2,36E-003
2830001	1,98E-003
2840001	2,82E-003
2850001	2,01E-003
2860001	1,69E-003
2870001	3,00E-003
2880001	1,71E-003
2890001	2,03E-003
2900001	2,60E-003
2910001	1,94E-003
2920001	2,12E-003
2930001	2,97E-003
2940001	1,68E-003
2950001	1,92E-003
2960001	2,63E-003
2970001	1,85E-003
2980001	1,86E-003
2990001	2,57E-003
3000001	1,76E-003



1.3 Segunda Solución DyV

En esta segunda solución que planteamos para nuestro problema comenzaremos como en la anterior, presentando el código:

```
#include <iostream>
using namespace std;
#include <ctime>
#include <cstdlib>
#include <climits>
#include <cassert>
//#include <mach/mach_time.h>
#include <cstdio>
#include <chrono>

int &  rift_lims(int* arr, int beg, int end, int & res){

  int N = end - beg;

  if (N  == 1) {
    res = beg;
    return arr[beg];
  }
  else if (arr [beg + N/2 - 1] < arr [end - 1])
    return rift_lims(arr, beg + N/2 , end, res);
  else
    return rift_lims(arr,beg, beg + N/2, res);
}
```

```
int rift(int * arr, int n, int & res){

  int beg = 0, end = n;

  return rift_lims(arr,beg,end,res);
}

double uniforme()
{
double u;
  u = (double) rand();
  u = u/(double)(RAND_MAX+1.0);
 return u;
}

int main(int argc, char * argv[])
{

  if (argc != 2)
    {
      cerr << "Formato " << argv[0] << " <num_elem>" << endl;
      return -1;
    }

  int n = atoi(argv[1]);

  int * T = new int[n];
  assert(T);

  srand(time(0));
  double u=uniforme();
  int p=1+(int)((n-2)*u);
  T[p]=n-1;
  for (int i=0; i<p; i++) T[i]=i;
  for (int i=p+1; i<n; i++) T[i]=n-1-i+p;

#ifdef _PRINT_IT_
  cout << "El vector generado es:" << endl;
  for (int j=0; j<n; j++) {cout << T[j] << " ";}
  cout << endl;
#endif

int res=0;
std::chrono::high_resolution_clock::time_point t1, t2;

t1=std::chrono::high_resolution_clock::now();
rift(T,n,res);
t2=std::chrono::high_resolution_clock::now();
int punto_cambio=res;

std::chrono::duration<double>                                    transcurrido                                    =
std::chrono::duration_cast<std::chrono::duration<double> >(t2-t1);
```

```
cout << n << " " << transcurrido.count() << "\n";

#ifdef _PRINT_IT_
cout << endl << "La posicion en la que cambia la monotonia es: " << punto_cambio << endl ;
#endif
}
```

El algoritmo utilizado en esta segunda solución es el siguiente:
1) Aprovechando la estructura con la que se genera el vector aleatorio tomamos inicialmente el punto medio y el extremo derecho del vector. Si el valor almacenado en el punto medio es mayor que el almacenado en el punto extremo tomamos la parte izquierda del vector. Si el valor almacenado en el punto medio es menor que el del extremo tomaremos la parte derecha del vector.
2) Repetiremos esto hasta llegar al caso en que el tamaño del vector sea 1 y por tanto el punto sea el único que nos queda.

La eficiencia de este algoritmo es logarítmica como se observa en la suma al cuadrado de los residuos que nos arroja el ajuste de las funciones mediante gnuplot:
nlogarítmica = 1.0888e-10
logarítmica = 6.58058e-11

Pasamos a exponer los datos y gráficas obtenidas:

Datos:
-**Tabla y gŕafica de Nacho(Toshiba,Linux):**

Tamaño	Tiempo
1	1.34e-07
5001	3.71e-07
10001	4.65e-07
15001	7.23e-07
20001	5.42e-07
25001	5.18e-07
30001	6.48e-07
35001	6.85e-07
40001	6.48e-07
45001	7.77e-07
50001	1,01E-003
55001	8,00E-007
60001	1,65E-003
65001	1,30E-003
70001	1,51E-003
75001	1,08E-003
80001	9.79e-07
85001	1,08E-003

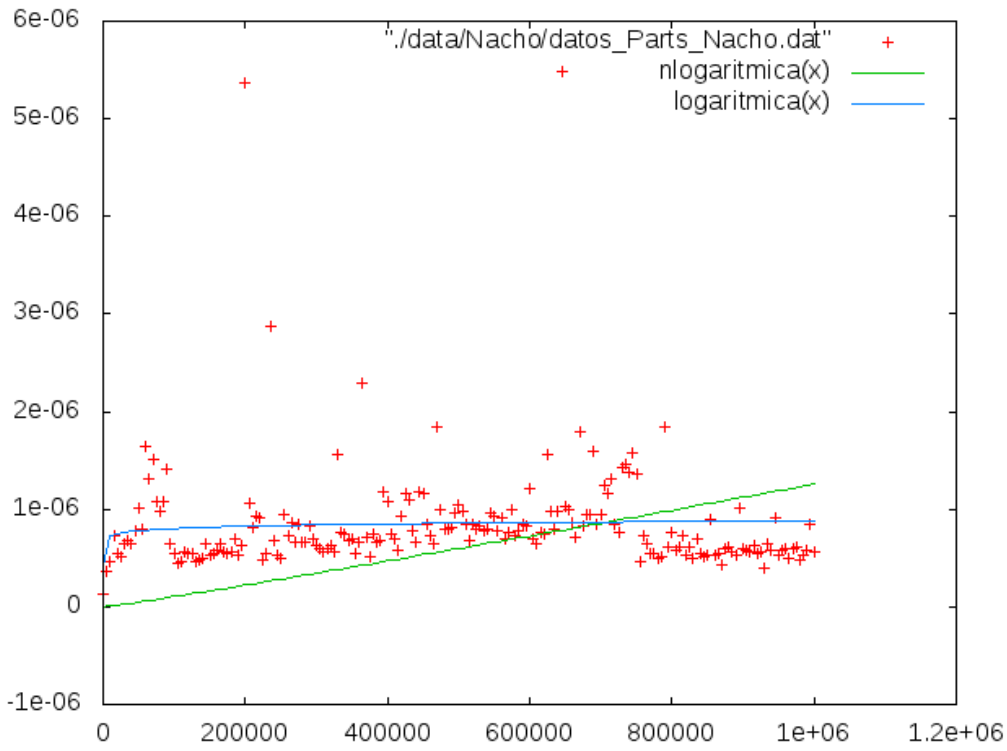
90001	1,40E-003
95001	6.52e-07
100001	5.43e-07
105001	4.48e-07
110001	4.66e-07
115001	5.67e-07
120001	5.42e-07
125001	5.41e-07
130001	4.64e-07
135001	4.82e-07
140001	4.95e-07
145001	6.45e-07
150001	5.29e-07
155001	5.54e-07
160001	5.85e-07
165001	6.48e-07
170001	5.65e-07
175001	5.44e-07
180001	5.57e-07
185001	6.91e-07
190001	5.38e-07
195001	6.32e-07
200001	5,37E-003
205001	1.06e-06
210001	8.08e-07
215001	9.24e-07
220001	9.12e-07
225001	4.86e-07
230001	5.44e-07
235001	2,87E-003
240001	6.74e-07
245001	5.3e-07
250001	4.99e-07
255001	9.51e-07
260001	7.32e-07
265001	8.61e-07
270001	6.55e-07

275001	8.5e-07
280001	6.63e-07
285001	6.71e-07
290001	8.31e-07
295001	6.98e-07
300001	6.29e-07
305001	6.02e-07
310001	5.59e-07
315001	5.97e-07
320001	6.24e-07
325001	5.7e-07
330001	1,57E-003
335001	7.67e-07
340001	7.46e-07
345001	6.87e-07
350001	6.92e-07
355001	5.52e-07
360001	6.64e-07
365001	2,30E-003
370001	7.07e-07
375001	5.12e-07
380001	7.48e-07
385001	6.69e-07
390001	6.86e-07
395001	1,18E-003
400001	1,07E-003
405001	7.38e-07
410001	6.94e-07
415001	5.86e-07
420001	9.21e-07
425001	1,16E-003
430001	1,10E-003
435001	7.87e-07
440001	6.62e-07
445001	1,18E-003
450001	1,17E-003
455001	8.52e-07

460001	7.28e-07
465001	6.49e-07
470001	1,85E-003
475001	9.92e-07
480001	7.9e-07
485001	7.95e-07
490001	8.13e-07
495001	9.6e-07
500001	1,04E-003
505001	9.72e-07
510001	8.53e-07
515001	6.87e-07
520001	8.4e-07
525001	8.02e-07
530001	8.37e-07
535001	7.8e-07
540001	7.9e-07
545001	9.61e-07
550001	9.27e-07
555001	7.75e-07
560001	9.06e-07
565001	6.97e-07
570001	7.61e-07
575001	9.99e-07
580001	7.22e-07
585001	7.76e-07
590001	8.43e-07
595001	8.35e-07
600001	1,22E-003
605001	6.98e-07
610001	6.41e-07
615001	7.57e-07
620001	7.51e-07
625001	1,57E-003
630001	9.71e-07
635001	7.9e-07
640001	9.72e-07

645001	5,49E-003
650001	1,03E-003
655001	9.92e-07
660001	8.6e-07
665001	7.13e-07
670001	1,79E-003
675001	8.22e-07
680001	9.47e-07
685001	9.41e-07
690001	1.6e-06
695001	8.41e-07
700001	9.45e-07
705001	1,24E-003
710001	1,17E-003
715001	1,30E-003
720001	8.45e-07
725001	7.68e-07
730001	1,43E-003
735001	1,46E-003
740001	1,38E-003
745001	1,58E-003
750001	1,36E-003
755001	4.69e-07
760001	7.21e-07
765001	6.44e-07
770001	5.44e-07
775001	5.45e-07
780001	5.01e-07
785001	5.1e-07
790001	1,85E-003
795001	6.2e-07
800001	7.57e-07
805001	5.77e-07
810001	6.05e-07
815001	7.31e-07
820001	5.32e-07
825001	6.13e-07

830001	4.91e-07
835001	7.02e-07
840001	5.54e-07
845001	5.18e-07
850001	5.25e-07
855001	8.97e-07
860001	5.38e-07
865001	5.45e-07
870001	4.3e-07
875001	5.95e-07
880001	6.2e-07
885001	5.57e-07
890001	5.27e-07
895001	1,01E-003
900001	5.95e-07
905001	5.87e-07
910001	5.57e-07
915001	6.36e-07
920001	5.43e-07
925001	5.71e-07
930001	4.02e-07
935001	6.4e-07
940001	5.78e-07
945001	9.07e-07
950001	5.37e-07
955001	5.78e-07
960001	6.04e-07
965001	5.02e-07
970001	5.95e-07
975001	6.16e-07
980001	4.86e-07
985001	5.34e-07
990001	5.72e-07
995001	8.5e-07
1000001	5.71e-07



-**Tabla y gŕafica de Luis(Fujitsu,Linux):**

Tamaño	Tiempo
1	2.19e-07
5001	4.42e-07
10001	4.13e-07
15001	4.04e-07
20001	4.16e-07
25001	4.43e-07
30001	4.42e-07
35001	5.34e-07
40001	4.08e-07
45001	9.12e-07
50001	6.3e-07
55001	8.93e-07
60001	4.91e-07
65001	4.79e-07
70001	5.8e-07
75001	5.62e-07
80001	5.65e-07
85001	5.3e-07

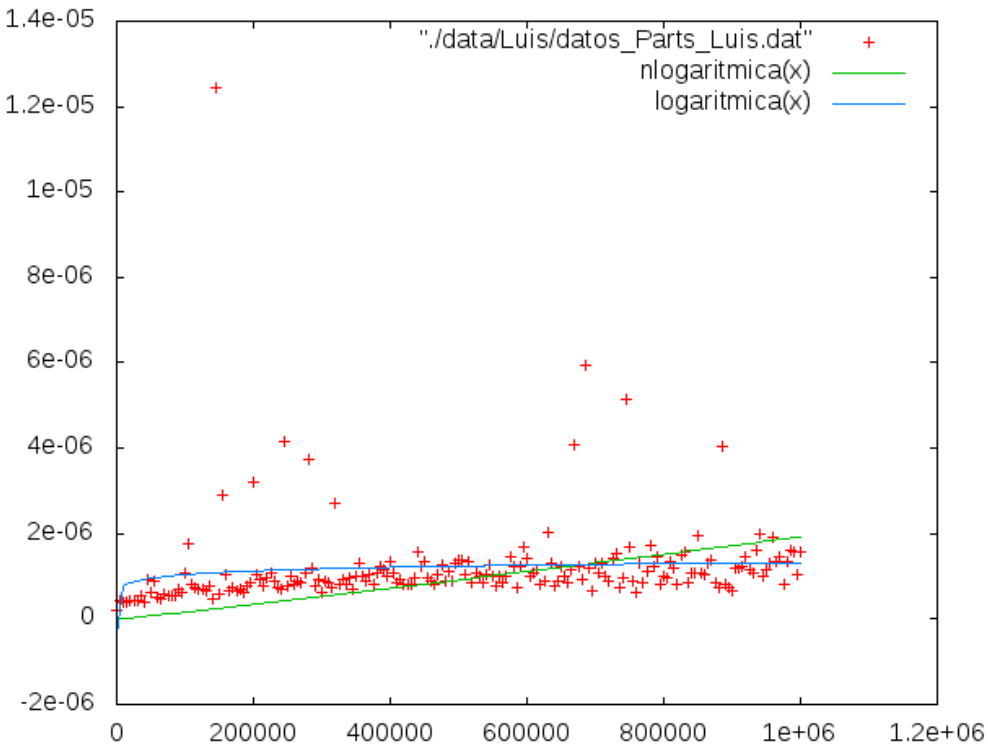
90001	6.8e-07
95001	6.4e-07
100001	1,09E-003
105001	1,77E-003
110001	8.01e-07
115001	7.36e-07
120001	7.04e-07
125001	7.07e-07
130001	6.76e-07
135001	7.59e-07
140001	4.74e-07
145001	1.2453e-05
150001	5.95e-07
155001	2,91E-003
160001	1,05E-003
165001	6.61e-07
170001	7.47e-07
175001	6.63e-07
180001	7.07e-07
185001	6.28e-07
190001	7.89e-07
195001	8.39e-07
200001	3,21E-003
205001	1,03E-003
210001	9.16e-07
215001	7.6e-07
220001	9.73e-07
225001	1,06E-003
230001	8.9e-07
235001	7.19e-07
240001	7.15e-07
245001	4,16E-003
250001	7.56e-07
255001	9.84e-07
260001	8.19e-07
265001	8.82e-07
270001	8.69e-07

275001	1,07E-003
280001	3,73E-003
285001	1,18E-003
290001	7.71e-07
295001	9.32e-07
300001	6.11e-07
305001	9.04e-07
310001	8.47e-07
315001	7.55e-07
320001	2,69E-003
325001	8.17e-07
330001	9.2e-07
335001	7.97e-07
340001	9.46e-07
345001	7.06e-07
350001	1,01E-003
355001	1.3e-06
360001	1,01E-003
365001	8.94e-07
370001	1,04E-003
375001	8.23e-07
380001	1,07E-003
385001	1,24E-003
390001	1,16E-003
395001	1,01E-003
400001	1,35E-003
405001	1,09E-003
410001	8.66e-07
415001	9.32e-07
420001	7.98e-07
425001	8.2e-07
430001	8.13e-07
435001	9.59e-07
440001	1,58E-003
445001	1.24e-06
450001	1,34E-003
455001	9.76e-07

460001	9.02e-07
465001	8.29e-07
470001	1,06E-003
475001	1,26E-003
480001	9.03e-07
485001	1,13E-003
490001	8.8e-07
495001	1,32E-003
500001	1,38E-003
505001	1,37E-003
510001	1,05E-003
515001	1,33E-003
520001	8.37e-07
525001	1,06E-003
530001	9.95e-07
535001	8.42e-07
540001	1,06E-003
545001	1,27E-003
550001	1,02E-003
555001	7.93e-07
560001	1,01E-003
565001	8.61e-07
570001	9.86e-07
575001	1,46E-003
580001	1,23E-003
585001	7.21e-07
590001	1,22E-003
595001	1,67E-003
600001	1,43E-003
605001	9.9e-07
610001	1,07E-003
615001	1,15E-003
620001	8.14e-07
625001	8.82e-07
630001	2,02E-003
635001	1,31E-003
640001	7.59e-07

645001	8.73e-07
650001	1,24E-003
655001	1,02E-003
660001	8.39e-07
665001	1,17E-003
670001	4,10E-003
675001	1,21E-003
680001	9.38e-07
685001	5,95E-003
690001	1,20E-003
695001	6.64e-07
700001	1,32E-003
705001	1,07E-003
710001	1.3e-06
715001	9.98e-07
720001	8.94e-07
725001	1,43E-003
730001	1,55E-003
735001	7.43e-07
740001	9.66e-07
745001	5,13E-003
750001	1.69e-06
755001	8.74e-07
760001	6.24e-07
765001	1,29E-003
770001	8.49e-07
775001	1,13E-003
780001	1,73E-003
785001	1,24E-003
790001	1,46E-003
795001	8.03e-07
800001	9.92e-07
805001	9.59e-07
810001	1,35E-003
815001	1,21E-003
820001	8.3e-07
825001	1.49e-06

830001	1,58E-003
835001	8.47e-07
840001	1,09E-003
845001	1,07E-003
850001	1.94e-06
855001	1,07E-003
860001	1,05E-003
865001	1,31E-003
870001	1,38E-003
875001	8.39e-07
880001	7.52e-07
885001	4,03E-003
890001	8.14e-07
895001	7.49e-07
900001	6.65e-07
905001	1,19E-003
910001	1,18E-003
915001	1,22E-003
920001	1,45E-003
925001	1,16E-003
930001	1,07E-003
935001	1,59E-003
940001	1,97E-003
945001	9.96e-07
950001	1,15E-003
955001	1,29E-003
960001	1,92E-003
965001	1,33E-003
970001	1,48E-003
975001	8.06e-07
980001	1.33e-06
985001	1.62e-06
990001	1,56E-003
995001	1,04E-003
1000001	1,58E-003



-<u>Tabla y gŕafica de Miguel(Toshiba, Windows):</u>

Tamaño	Tiempo
1	0,00E+000
10001	4.27654e-007
20001	4.27654e-007
30001	0,00E+000
40001	4.27654e-007
50001	4.27654e-007
60001	4.27654e-007
70001	4.27654e-007
80001	0,00E+000
90001	4.27654e-007
100001	4.27654e-007
110001	4.27654e-007
120001	0,00E+000
130001	4.27654e-007
140001	4.27654e-007
150001	4.27654e-007
160001	0,00E+000
170001	4.27654e-007

180001	4.27654e-007
190001	4.27654e-007
200001	4.27654e-007
210001	4.27654e-007
220001	0,00E+000
230001	4.27654e-007
240001	0,00E+000
250001	4.27654e-007
260001	4.27654e-007
270001	4.27654e-007
280001	4.27654e-007
290001	4.27654e-007
300001	4.27654e-007
310001	4.27654e-007
320001	0,00E+000
330001	4.27654e-007
340001	4.27654e-007
350001	0,00E+000
360001	4.27654e-007
370001	0,00E+000
380001	0,00E+000
390001	4.27654e-007
400001	4.27654e-007
410001	4.27654e-007
420001	4.27654e-007
430001	4.27654e-007
440001	4.27654e-007
450001	4.27654e-007
460001	4.27654e-007
470001	0,00E+000
480001	4.27654e-007
490001	4.27654e-007
500001	4.27654e-007
510001	4.27654e-007
520001	4.27654e-007
530001	4.27654e-007
540001	8.55308e-007

550001	4.27654e-007
560001	4.27654e-007
570001	4.27654e-007
580001	4.27654e-007
590001	4.27654e-007
600001	4.27654e-007
610001	4.27654e-007
620001	8.55308e-007
630001	4.27654e-007
640001	4.27654e-007
650001	8.55308e-007
660001	4.27654e-007
670001	4.27654e-007
680001	4.27654e-007
690001	1.71062e-006
700001	4.27654e-007
710001	4.27654e-007
720001	4.27654e-007
730001	4.27654e-007
740001	4.27654e-007
750001	4.27654e-007
760001	8.55308e-007
770001	4.27654e-007
780001	4.27654e-007
790001	4.27654e-007
800001	8.55308e-007
810001	4.27654e-007
820001	4.27654e-007
830001	4.27654e-007
840001	4.27654e-007
850001	4.27654e-007
860001	4.27654e-007
870001	4.27654e-007
880001	8.55308e-007
890001	4.27654e-007
900001	4.27654e-007
910001	4.27654e-007

920001	4.27654e-007
930001	8.55308e-007
940001	4.27654e-007
950001	4.27654e-007
960001	8.55308e-007
970001	4.27654e-007
980001	2.13827e-006
990001	4.27654e-007
1000001	8.55308e-007
1010001	4.27654e-007
1020001	4.27654e-007
1030001	4.27654e-007
1040001	4.27654e-007
1050001	8.55308e-007
1060001	4.27654e-007
1070001	4.27654e-007
1080001	4.27654e-007
1090001	4.27654e-007
1100001	4.27654e-007
1110001	4.27654e-007
1120001	4.27654e-007
1130001	4.27654e-007
1140001	4.27654e-007
1150001	4.27654e-007
1160001	4.27654e-007
1170001	4.27654e-007
1180001	4.27654e-007
1190001	4.27654e-007
1200001	4.27654e-007
1210001	4.27654e-007
1220001	4.27654e-007
1230001	4.27654e-007
1240001	4.27654e-007
1250001	1.28296e-006
1260001	4.27654e-007
1270001	4.27654e-007
1280001	4.27654e-007

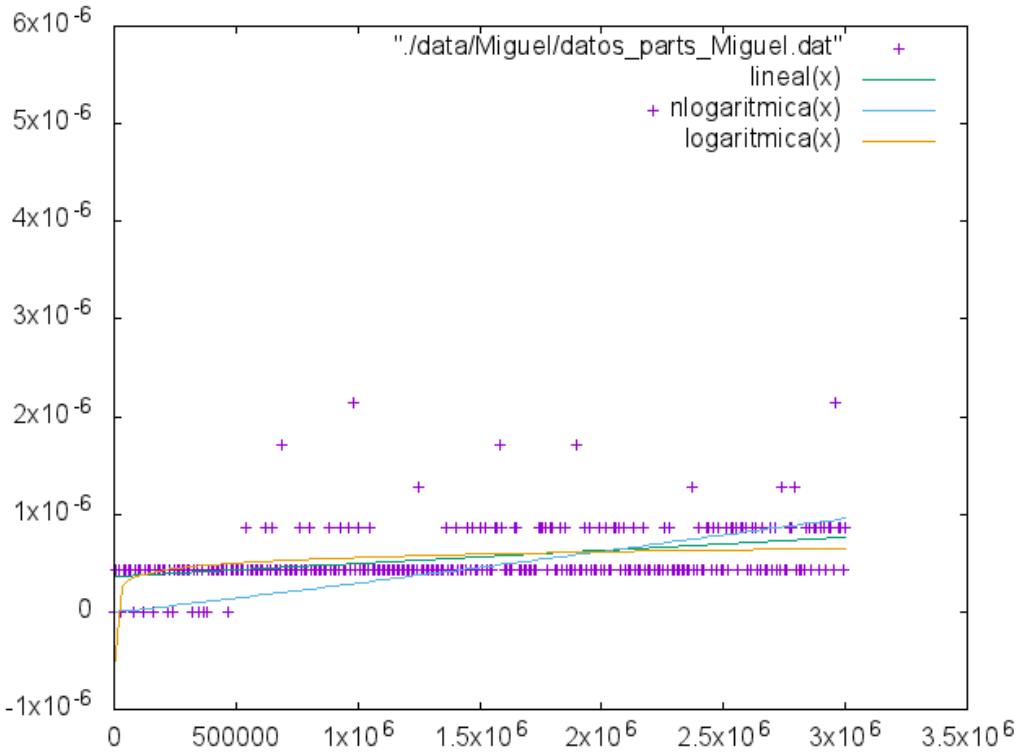
1290001	4.27654e-007
1300001	4.27654e-007
1310001	4.27654e-007
1320001	4.27654e-007
1330001	4.27654e-007
1340001	4.27654e-007
1350001	4.27654e-007
1360001	8.55308e-007
1370001	4.27654e-007
1380001	4.27654e-007
1390001	4.27654e-007
1400001	8.55308e-007
1410001	4.27654e-007
1420001	4.27654e-007
1430001	4.27654e-007
1440001	4.27654e-007
1450001	8.55308e-007
1460001	4.27654e-007
1470001	8.55308e-007
1480001	4.27654e-007
1490001	4.27654e-007
1500001	8.55308e-007
1510001	4.27654e-007
1520001	8.55308e-007
1530001	4.27654e-007
1540001	4.27654e-007
1550001	4.27654e-007
1560001	8.55308e-007
1570001	8.55308e-007
1580001	1.71062e-006
1590001	8.55308e-007
1600001	4.27654e-007
1610001	4.27654e-007
1620001	4.27654e-007
1630001	4.27654e-007
1640001	8.55308e-007
1650001	8.55308e-007

1660001	4.27654e-007
1670001	4.27654e-007
1680001	4.27654e-007
1690001	4.27654e-007
1700001	4.27654e-007
1710001	4.27654e-007
1720001	4.27654e-007
1730001	4.27654e-007
1740001	8.55308e-007
1750001	8.55308e-007
1760001	8.55308e-007
1770001	8.55308e-007
1780001	4.27654e-007
1790001	8.55308e-007
1800001	8.55308e-007
1810001	4.27654e-007
1820001	4.27654e-007
1830001	8.55308e-007
1840001	4.27654e-007
1850001	8.55308e-007
1860001	4.27654e-007
1870001	4.27654e-007
1880001	4.27654e-007
1890001	4.27654e-007
1900001	1.71062e-006
1910001	4.27654e-007
1920001	4.27654e-007
1930001	8.55308e-007
1940001	4.27654e-007
1950001	8.55308e-007
1960001	4.27654e-007
1970001	4.27654e-007
1980001	4.27654e-007
1990001	8.55308e-007
2000001	4.27654e-007
2010001	4.27654e-007
2020001	8.55308e-007

2030001	4.27654e-007
2040001	4.27654e-007
2050001	8.55308e-007
2060001	8.55308e-007
2070001	8.55308e-007
2080001	4.27654e-007
2090001	8.55308e-007
2100001	4.27654e-007
2110001	4.27654e-007
2120001	4.27654e-007
2130001	8.55308e-007
2140001	4.27654e-007
2150001	4.27654e-007
2160001	4.27654e-007
2170001	8.55308e-007
2180001	4.27654e-007
2190001	4.27654e-007
2200001	4.27654e-007
2210001	5.13185e-006
2220001	4.27654e-007
2230001	4.27654e-007
2240001	4.27654e-007
2250001	4.27654e-007
2260001	8.55308e-007
2270001	4.27654e-007
2280001	8.55308e-007
2290001	4.27654e-007
2300001	4.27654e-007
2310001	4.27654e-007
2320001	4.27654e-007
2330001	4.27654e-007
2340001	4.27654e-007
2350001	4.27654e-007
2360001	4.27654e-007
2370001	1.28296e-006
2380001	4.27654e-007
2390001	4.27654e-007

2400001	8.55308e-007
2410001	4.27654e-007
2420001	4.27654e-007
2430001	8.55308e-007
2440001	8.55308e-007
2450001	4.27654e-007
2460001	8.55308e-007
2470001	4.27654e-007
2480001	8.55308e-007
2490001	4.27654e-007
2500001	4.27654e-007
2510001	8.55308e-007
2520001	4.27654e-007
2530001	8.55308e-007
2540001	8.55308e-007
2550001	8.55308e-007
2560001	4.27654e-007
2570001	8.55308e-007
2580001	8.55308e-007
2590001	8.55308e-007
2600001	4.27654e-007
2610001	4.27654e-007
2620001	8.55308e-007
2630001	8.55308e-007
2640001	4.27654e-007
2650001	4.27654e-007
2660001	8.55308e-007
2670001	4.27654e-007
2680001	4.27654e-007
2690001	8.55308e-007
2700001	4.27654e-007
2710001	8.55308e-007
2720001	4.27654e-007
2730001	4.27654e-007
2740001	1.28296e-006
2750001	4.27654e-007
2760001	4.27654e-007

2770001	8.55308e-007
2780001	8.55308e-007
2790001	1.28296e-006
2800001	4.27654e-007
2810001	4.27654e-007
2820001	4.27654e-007
2830001	4.27654e-007
2840001	8.55308e-007
2850001	8.55308e-007
2860001	4.27654e-007
2870001	8.55308e-007
2880001	8.55308e-007
2890001	4.27654e-007
2900001	8.55308e-007
2910001	8.55308e-007
2920001	4.27654e-007
2930001	8.55308e-007
2940001	8.55308e-007
2950001	4.27654e-007
2960001	2.13827e-006
2970001	8.55308e-007
2980001	8.55308e-007
2990001	4.27654e-007
3000001	8.55308e-007



-<u>Tabla y gráfica de Diego(MacBook Pro,MacOS El Capitán):</u>

Tamaño	Tiempo
1	2.34e-07
5001	6.35e-07
10001	6.9e-07
15001	5.58e-07
20001	5.28e-07
25001	6.74e-07
30001	5.33e-07
35001	5.96e-07
40001	7.28e-07
45001	6.3e-07
50001	5.86e-07
55001	6.07e-07
60001	8.7e-07
65001	7.1e-07
70001	8.5e-07
75001	8.11e-07
80001	6.72e-07
85001	8.74e-07
90001	6.72e-07

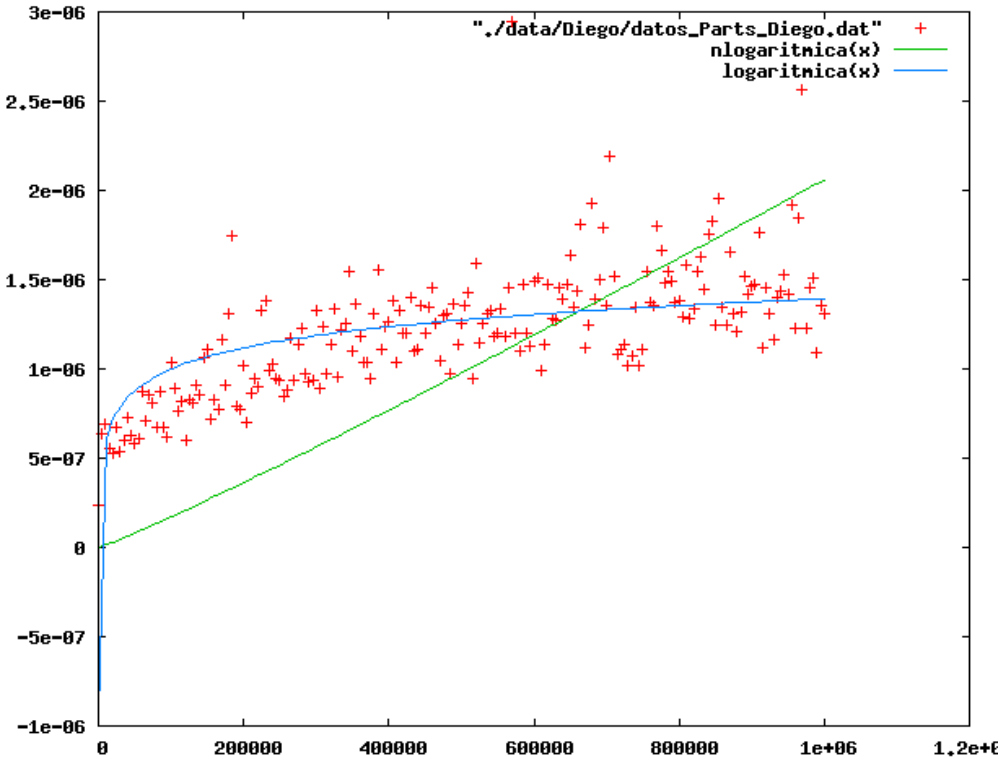
95001	6.14e-07
100001	1,04E-003
105001	8.95e-07
110001	7.66e-07
115001	8.16e-07
120001	6.03e-07
125001	8.28e-07
130001	8.11e-07
135001	9.06e-07
140001	8.57e-07
145001	1,07E-003
150001	1,11E-003
155001	7.15e-07
160001	8.27e-07
165001	7.7e-07
170001	1,16E-003
175001	9.08e-07
180001	1.31e-06
185001	1,74E-003
190001	7.88e-07
195001	7.76e-07
200001	1,02E-003
205001	7.02e-07
210001	8.63e-07
215001	9.41e-07
220001	8.99e-07
225001	1.33e-06
230001	1,38E-003
235001	9.95e-07
240001	1,03E-003
245001	9.44e-07
250001	9.38e-07
255001	8.46e-07
260001	8.86e-07
265001	1,18E-003
270001	9.37e-07
275001	1,14E-003

280001	1,23E-003
285001	9.73e-07
290001	9.31e-07
295001	9.39e-07
300001	1,32E-003
305001	8.88e-07
310001	1,24E-003
315001	9.73e-07
320001	1,13E-003
325001	1,34E-003
330001	9.59e-07
335001	1,22E-003
340001	1,26E-003
345001	1,55E-003
350001	1,10E-003
355001	1,36E-003
360001	1,18E-003
365001	1,04E-003
370001	1,04E-003
375001	9.46e-07
380001	1,31E-003
385001	1,55E-003
390001	1,11E-003
395001	1,24E-003
400001	1,27E-003
405001	1.38e-06
410001	1,03E-003
415001	1,33E-003
420001	1,20E-003
425001	1,20E-003
430001	1,40E-003
435001	1,10E-003
440001	1,11E-003
445001	1,36E-003
450001	1,20E-003
455001	1,35E-003
460001	1,45E-003

465001	1,25E-003
470001	1,05E-003
475001	1,30E-003
480001	1,31E-003
485001	9.73e-07
490001	1,36E-003
495001	1,14E-003
500001	1,25E-003
505001	1,35E-003
510001	1,42E-003
515001	9.46e-07
520001	1.59e-06
525001	1,14E-003
530001	1,26E-003
535001	1,31E-003
540001	1,33E-003
545001	1,18E-003
550001	1,20E-003
555001	1,34E-003
560001	1,18E-003
565001	1,46E-003
570001	2,94E-003
575001	1,20E-003
580001	1,10E-003
585001	1,47E-003
590001	1,20E-003
595001	1,13E-003
600001	1,50E-003
605001	1,51E-003
610001	9.87e-07
615001	1,14E-003
620001	1,47E-003
625001	1,28E-003
630001	1.27e-06
635001	1,46E-003
640001	1,40E-003
645001	1,48E-003

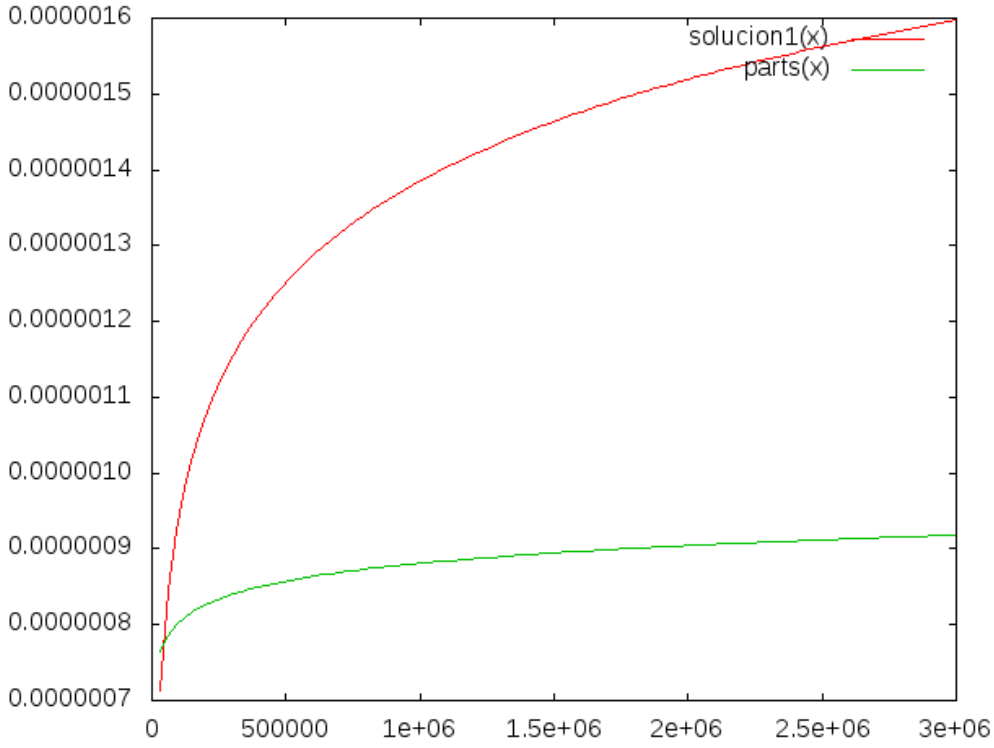
650001	1,63E-003
655001	1,34E-003
660001	1,44E-003
665001	1,81E-003
670001	1,11E-003
675001	1,25E-003
680001	1,93E-003
685001	1,39E-003
690001	1,50E-003
695001	1,79E-003
700001	1,36E-003
705001	2,19E-003
710001	1,52E-003
715001	1,08E-003
720001	1,11E-003
725001	1.14e-06
730001	1,02E-003
735001	1,08E-003
740001	1,35E-003
745001	1,02E-003
750001	1,11E-003
755001	1,55E-003
760001	1,37E-003
765001	1,36E-003
770001	1,80E-003
775001	1,66E-003
780001	1,48E-003
785001	1,54E-003
790001	1,49E-003
795001	1,38E-003
800001	1,39E-003
805001	1,29E-003
810001	1,58E-003
815001	1,28E-003
820001	1,34E-003
825001	1,55E-003
830001	1,63E-003

835001	1,45E-003
840001	1,76E-003
845001	1,82E-003
850001	1,25E-003
855001	1,96E-003
860001	1,35E-003
865001	1,24E-003
870001	1,65E-003
875001	1,31E-003
880001	1,21E-003
885001	1.32e-06
890001	1,52E-003
895001	1,42E-003
900001	1,46E-003
905001	1,47E-003
910001	1,77E-003
915001	1,12E-003
920001	1.45e-06
925001	1,31E-003
930001	1,17E-003
935001	1,40E-003
940001	1,44E-003
945001	1,52E-003
950001	1,42E-003
955001	1,92E-003
960001	1,23E-003
965001	1,85E-003
970001	2,57E-003
975001	1.23e-06
980001	1.45e-06
985001	1,51E-003
990001	1,09E-003
995001	1,35E-003
1000001	1,31E-003



1.4 Comparación entre algoritmos

Para la comparación nos valdremos de la función logarítmica que hemos ajustado para la primera y la segunda solución DyV planteadas en la resolución del problema.



Como se puede observar en la gráfica la primera opción propuesta es menos eficiente que la segunda ya que la función ajustada y evaluada en el mismo rango de puntos perteneciente al primer algoritmo crece más rápido que la función ajustada para el segundo algoritmo.

2. Comparación de preferencias

El problema en este caso consiste en contar el número de inversiones que se producen en un vector considerándose como inversión que v[i]>v[j] con i<j.

2.1 Algoritmo Evidente

Comenzamos presentando el código del algoritmo:

```
#include <iostream>
using namespace std;
#include <ctime>
#include <cstdlib>
#include <climits>
#include <cassert>
#include <chrono>

double uniforme()
{
 int t = rand();
 double f = ((double)RAND_MAX+1.0);
 return (double)t/f;
}

int CuentaIntercambios(int* v, int tam)
{
  int inter=0;
  for(int i=0;i<tam;i++)
  {
    for(int j = i; j < tam;j++)
    {
      if(v[j]<v[i])
      {
        inter++;
      }
    }
  }
  return inter;
}


using namespace std::chrono;


int main(int argc, char * argv[])
{
```

```
 high_resolution_clock::time_point t1, t2;

 if (argc != 2)
  {
    cerr << "Formato " << argv[0] << " <num_elem>" << endl;
    return -1;
  }

 int n = atoi(argv[1]);

 int * T = new int[n];
 assert(T);

 srand(time(0));

 for (int j=0; j<n; j++) T[j]=j;
 for (int j=n-1; j>0; j--) {
   double u=uniforme();
   int k=(int)(j*u);
   int tmp=T[j];
   T[j]=T[k];
   T[k]=tmp;
 }
 for (int j=0; j<n; j++) {cout << T[j] << " ";}
 cout << endl;

 t1=high_resolution_clock::now();
 int valor = CuentaIntercambios(T,n);
 t2=high_resolution_clock::now();
 duration<double> transcurrido = duration_cast<duration<double> >(t2-t1);
 cout << "El número de inversiones es: " << valor << endl;
 cout << n << " " << transcurrido.count() << endl;


}
```

El algoritmo consiste en recorrer para cada uno de los índices el resto del vector comprobando si se produce la condición de inversión definida en el enunciado del ejercicio.

La eficiencia de este algoritmo como se puede observar en la suma al cuadrado de los residuos es cuadrática.

Cuadrática = 0.00112279
Logarítmica = 2.11738
nlogarítmica = 0.39753
Lineal = 0.239461

Presentamos aquí las tablas y gráficas:

Datos:
-**Tabla y gŕafica de Nacho(Toshiba,Linux):**

Tamaño	Tiempo

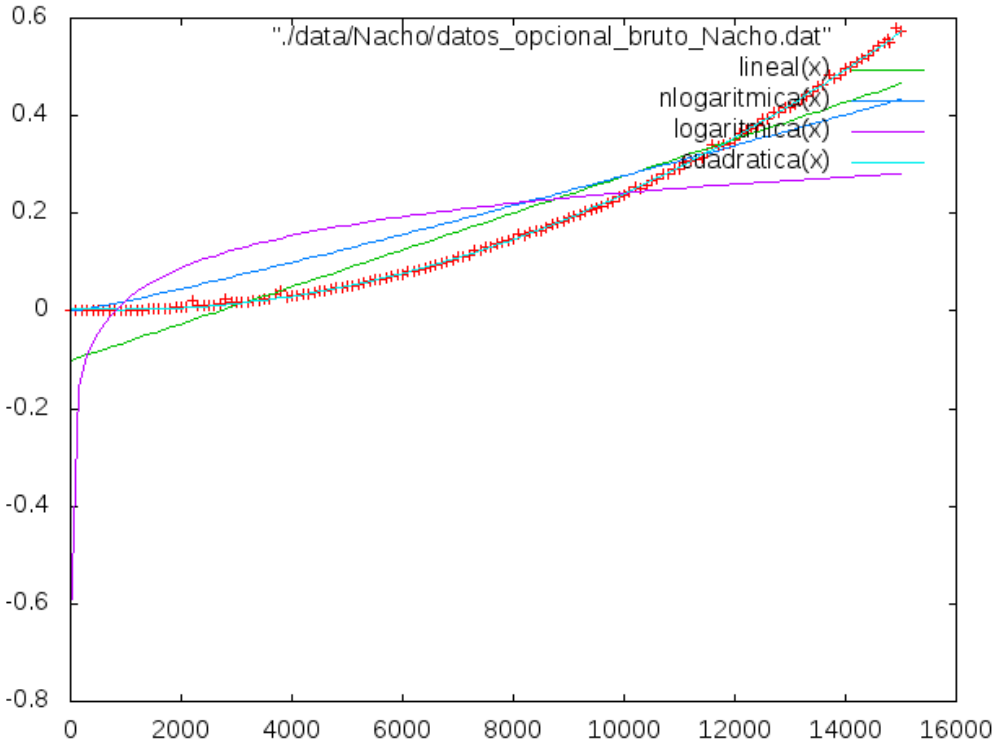
1	1.41e-07
101	2.5142e-05
201	0.000103164
301	0.000193621
401	0.000337938
501	0.000477668
601	0.000679365
701	0.000924468
801	0.00117381
901	0.00149671
1001	0.00183842
1101	0.00227849
1201	0.00257789
1301	0.00297941
1401	0.00351359
1501	0.00404629
1601	0.00475955
1701	0.00514748
1801	0.00579727
1901	0.00647466
2001	0.00720559
2101	0.00795875
2201	0.020742
2301	0.0100898
2401	0.0103839
2501	0.0112249
2601	0.0124864
2701	0.0135843
2801	0.025158
2901	0.0188092
3001	0.0166604
3101	0.0176471
3201	0.0190568
3301	0.0203796
3401	0.0214306
3501	0.0231602
3601	0.0247035

3701	0.0338897
3801	0.0402618
3901	0.0296734
4001	0.0305172
4101	0.0322395
4201	0.0344103
4301	0.0362872
4401	0.0385013
4501	0.0404516
4601	0.0419227
4701	0.0438269
4801	0.0496024
4901	0.0476108
5001	0.0497908
5101	0.0528444
5201	0.0555525
5301	0.0586841
5401	0.059652
5501	0.0640451
5601	0.0654455
5701	0.0677321
5801	0.0714792
5901	0.0759207
6001	0.0761982
6101	0.0802454
6201	0.0823885
6301	0.084693
6401	0.0887807
6501	0.0920634
6601	0.0942812
6701	0.096847
6801	0.101346
6901	0.104578
7001	0.1119
7101	0.110501
7201	0.11544
7301	0.122986

7401	0.123559
7501	0.1298
7601	0.129741
7701	0.139224
7801	0.141131
7901	0.144716
8001	0.146903
8101	0.156615
8201	0.153374
8301	0.160559
8401	0.165401
8501	0.165359
8601	0.17228
8701	0.177866
8801	0.182278
8901	0.185653
9001	0.19154
9101	0.194373
9201	0.198858
9301	0.204216
9401	0.206225
9501	0.212323
9601	0.214682
9701	0.222414
9801	0.225165
9901	0.23387
10001	0.237106
10101	0.244802
10201	0.254192
10301	0.251092
10401	0.25802
10501	0.267473
10601	0.271421
10701	0.279284
10801	0.27993
10901	0.291511
11001	0.292077

11101	0.304337
11201	0.307809
11301	0.309712
11401	0.313846
11501	0.325054
11601	0.339133
11701	0.336089
11801	0.339654
11901	0.344832
12001	0.351193
12101	0.362577
12201	0.369682
12301	0.372372
12401	0.380374
12501	0.395468
12601	0.395431
12701	0.406584
12801	0.407657
12901	0.417396
13001	0.418317
13101	0.425276
13201	0.4352
13301	0.440336
13401	0.449723
13501	0.460098
13601	0.463531
13701	0.485028
13801	0.47791
13901	0.484678
14001	0.497073
14101	0.500524
14201	0.509293
14301	0.51623
14401	0.524169
14501	0.532901
14601	0.54192
14701	0.551537

14801	0.550408
14901	0.57888
15001	0.572873



-**Tabla y gŕafica de Luis(Fujitsu,Linux):**

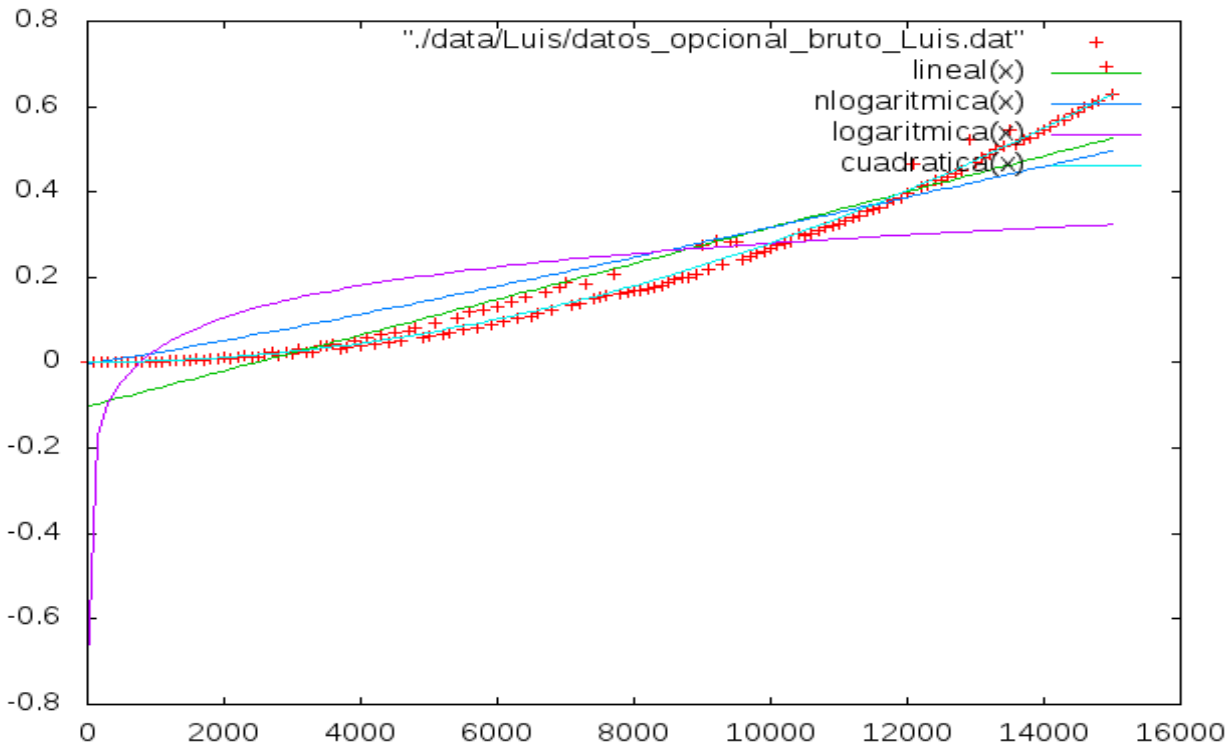
Tamaño	Tiempo
1	1.6e-07
101	2.8192e-05
201	0.000147707
301	0.000322543
401	0.00053221
501	0.000552182
601	0.00123978
701	0.00134266
801	0.00209974
901	0.00171646
1001	0.00327422
1101	0.00282971
1201	0.00479456
1301	0.00385254
1401	0.0063549

1501	0.00461788
1601	0.00851423
1701	0.00600093
1801	0.0102154
1901	0.00902456
2001	0.0126944
2101	0.00930031
2201	0.0117304
2301	0.0173308
2401	0.0126067
2501	0.0137294
2601	0.0223862
2701	0.0237495
2801	0.0182562
2901	0.0245377
3001	0.0194803
3101	0.0316626
3201	0.0241243
3301	0.0263231
3401	0.0405796
3501	0.0408961
3601	0.0434071
3701	0.0326005
3801	0.0348561
3901	0.0511171
4001	0.038446
4101	0.0574625
4201	0.0424753
4301	0.0653274
4401	0.0459118
4501	0.071764
4601	0.0514497
4701	0.0744898
4801	0.0817549
4901	0.0587425
5001	0.0626709
5101	0.0921241

5201	0.0679305
5301	0.0701484
5401	0.104526
5501	0.0770722
5601	0.118059
5701	0.0827904
5801	0.1247
5901	0.0901978
6001	0.131915
6101	0.096525
6201	0.141381
6301	0.103223
6401	0.153383
6501	0.110026
6601	0.114355
6701	0.166672
6801	0.125068
6901	0.176133
7001	0.188715
7101	0.134703
7201	0.14033
7301	0.186037
7401	0.149493
7501	0.15267
7601	0.15829
7701	0.207416
7801	0.162067
7901	0.164608
8001	0.168081
8101	0.169769
8201	0.17411
8301	0.178584
8401	0.182001
8501	0.189867
8601	0.19572
8701	0.198076
8801	0.201314

8901	0.207857
9001	0.274541
9101	0.21911
9201	0.285635
9301	0.228246
9401	0.284832
9501	0.283912
9601	0.241383
9701	0.250017
9801	0.255598
9901	0.259846
10001	0.266053
10101	0.274506
10201	0.278877
10301	0.28312
10401	0.300301
10501	0.298231
10601	0.302042
10701	0.308254
10801	0.319109
10901	0.320514
11001	0.325307
11101	0.332759
11201	0.340346
11301	0.344939
11401	0.353616
11501	0.358116
11601	0.364678
11701	0.374572
11801	0.382264
11901	0.385812
12001	0.396318
12101	0.465235
12201	0.411569
12301	0.417874
12401	0.428462
12501	0.428209

12601	0.436976
12701	0.443202
12801	0.450909
12901	0.523132
13001	0.467544
13101	0.480238
13201	0.490063
13301	0.498719
13401	0.508522
13501	0.544052
13601	0.511483
13701	0.523547
13801	0.526069
13901	0.537349
14001	0.545888
14101	0.554328
14201	0.566315
14301	0.568373
14401	0.583431
14501	0.586807
14601	0.596759
14701	0.607947
14801	0.614762
14901	0.694236
15001	0.628675



-Tabla y gŕafica de Miguel(Toshiba,Windows):

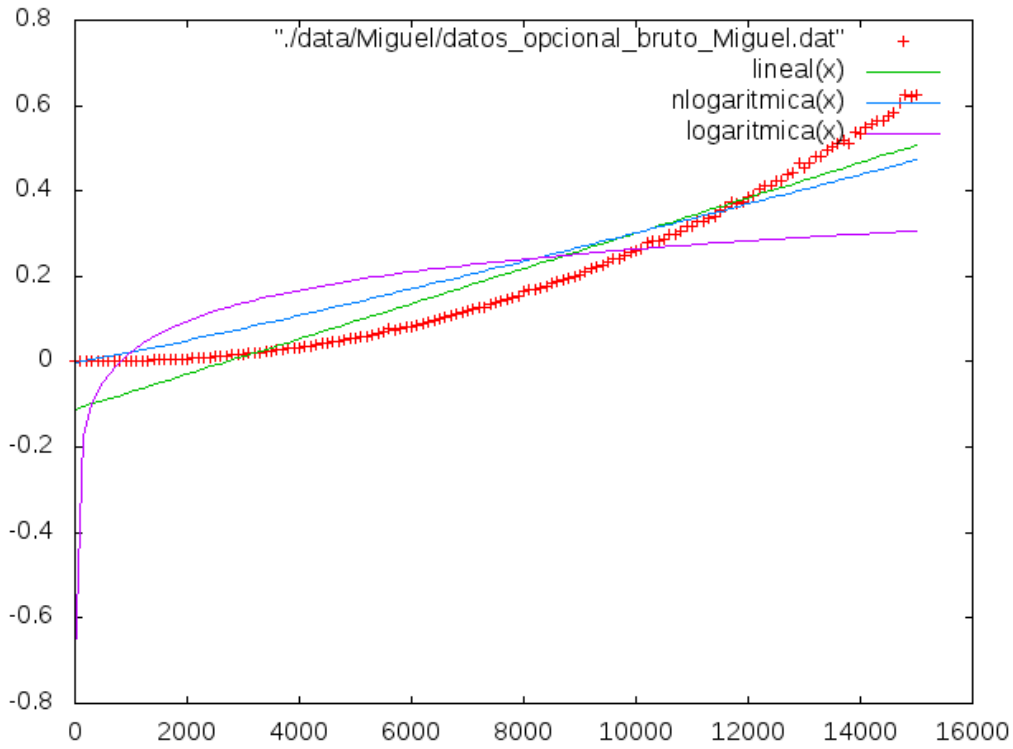
Tamaño	Tiempo
1	0,00E+000
101	3.67782e-005
201	0.000122309
301	0.000263007
401	0.000448181
501	0.000680397
601	0.00108923
701	0.00128382
801	0.00167298
901	0.00223235
1001	0.00203392
1101	0.0024928
1201	0.00282808
1301	0.00323862
1401	0.00437661
1501	0.00540255
1601	0.00660255
1701	0.00637504

1801	0.00623776
1901	0.0069776
2001	0.00758872
2101	0.00895422
2201	0.0092446
2301	0.0103625
2401	0.0112439
2501	0.0122912
2601	0.0132025
2701	0.0145749
2801	0.0156376
2901	0.0167773
3001	0.0184528
3101	0.0191743
3201	0.0207327
3301	0.0223107
3401	0.0237156
3501	0.026323
3601	0.0270577
3701	0.0295629
3801	0.0305324
3901	0.0322567
4001	0.0339574
4101	0.0367988
4201	0.0378812
4301	0.0399998
4401	0.0419067
4501	0.0441253
4601	0.0465185
4701	0.048676
4801	0.0513826
4901	0.0538066
5001	0.0562352
5101	0.0594589
5201	0.0603001
5301	0.0642956
5401	0.0663535

5501	0.0689973
5601	0.0768011
5701	0.074597
5801	0.0786721
5901	0.0815472
6001	0.0833562
6101	0.0867509
6201	0.0909479
6301	0.0935946
6401	0.0970287
6501	0.0999025
6601	0.103063
6701	0.108179
6801	0.111126
6901	0.115683
7001	0.118745
7101	0.124004
7201	0.128034
7301	0.128575
7401	0.133427
7501	0.137148
7601	0.141877
7701	0.148047
7801	0.149696
7901	0.154056
8001	0.163493
8101	0.167353
8201	0.168372
8301	0.17404
8401	0.176776
8501	0.184241
8601	0.188044
8701	0.190724
8801	0.194922
8901	0.199271
9001	0.204697
9101	0.210242

9201	0.216967
9301	0.221377
9401	0.2274
9501	0.23417
9601	0.241249
9701	0.243229
9801	0.247843
9901	0.254906
10001	0.260722
10101	0.2641
10201	0.280373
10301	0.284467
10401	0.283322
10501	0.288508
10601	0.296735
10701	0.297905
10801	0.306541
10901	0.316452
11001	0.318094
11101	0.3293
11201	0.330299
11301	0.337074
11401	0.341459
11501	0.355528
11601	0.363275
11701	0.373213
11801	0.370941
11901	0.376231
12001	0.384004
12101	0.389432
12201	0.40455
12301	0.411544
12401	0.411578
12501	0.422784
12601	0.425359
12701	0.439993
12801	0.441992

12901	0.464003
13001	0.455155
13101	0.463763
13201	0.481056
13301	0.480865
13401	0.495515
13501	0.504993
13601	0.509312
13701	0.518555
13801	0.512743
13901	0.53797
14001	0.535575
14101	0.549034
14201	0.557956
14301	0.564806
14401	0.562542
14501	0.575398
14601	0.583573
14701	0.607203
14801	0.62391
14901	0.622479
15001	0.626356



-<u>Tabla y gráfica de Diego(MacBook Pro,MacOS El Capitán):</u>

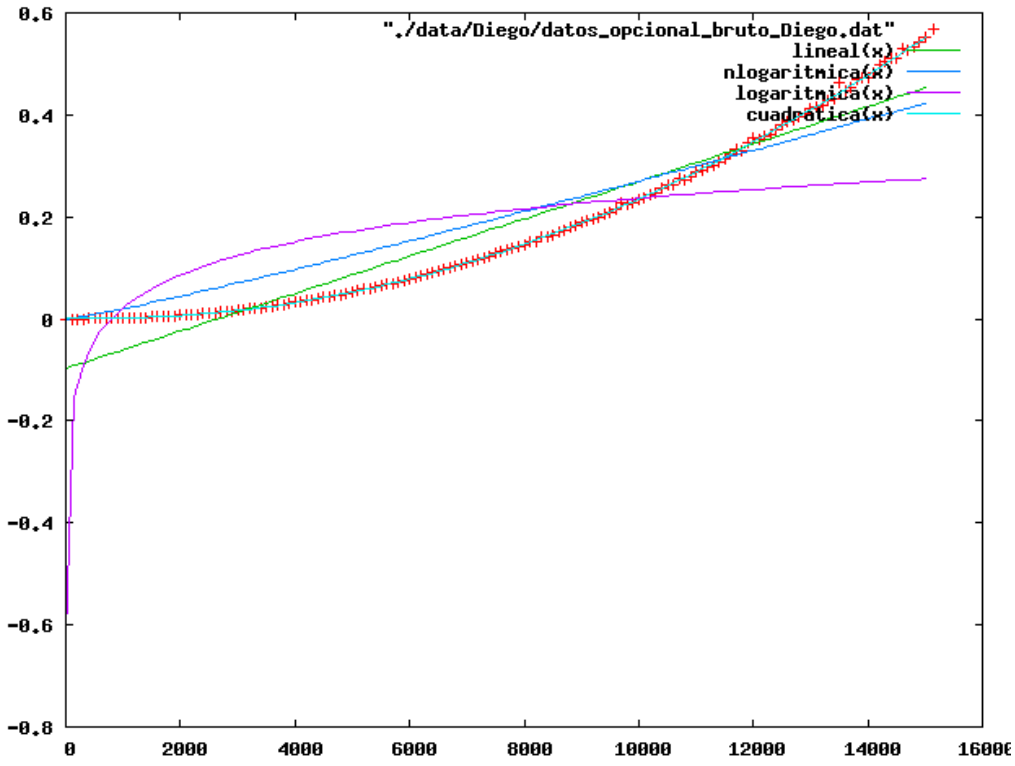
Tamaño	Tiempo
1	2.25e-07
101	2.4302e-05
201	8.1735e-05
301	0.000170414
401	0.000296484
501	0.000451955
601	0.000644197
701	0.000863413
801	0.00113277
901	0.00137309
1001	0.00172884
1101	0.00208632
1201	0.00247088
1301	0.00295514
1401	0.0033287
1501	0.00388584
1601	0.0043908
1701	0.00503627
1801	0.00566275

1901	0.00629676
2001	0.00807377
2101	0.00797816
2201	0.00862705
2301	0.0095215
2401	0.0103179
2501	0.0113802
2601	0.0121125
2701	0.0134044
2801	0.0143518
2901	0.0155613
3001	0.0187058
3101	0.0182389
3201	0.0213527
3301	0.0210211
3401	0.0222721
3501	0.0234907
3601	0.025179
3701	0.0266806
3801	0.02822
3901	0.0302005
4001	0.0322439
4101	0.033746
4201	0.0358188
4301	0.0377885
4401	0.0394659
4501	0.0420843
4601	0.0437907
4701	0.0459135
4801	0.0479473
4901	0.0501298
5001	0.052675
5101	0.0548173
5201	0.0586887
5301	0.0594106
5401	0.0621907
5501	0.0651138

5601	0.0692823
5701	0.0702256
5801	0.0723658
5901	0.0751053
6001	0.078383
6101	0.0811813
6201	0.0831296
6301	0.0864583
6401	0.0904768
6501	0.0928074
6601	0.0969403
6701	0.100301
6801	0.104771
6901	0.10637
7001	0.109353
7101	0.112116
7201	0.116381
7301	0.119558
7401	0.123646
7501	0.12981
7601	0.132739
7701	0.136115
7801	0.137682
7901	0.142392
8001	0.145664
8101	0.150156
8201	0.152686
8301	0.159602
8401	0.162112
8501	0.16568
8601	0.172043
8701	0.173587
8801	0.179724
8901	0.183676
9001	0.189255
9101	0.19117
9201	0.195654

9301	0.200319
9401	0.204126
9501	0.209585
9601	0.216573
9701	0.22744
9801	0.225042
9901	0.228409
10001	0.233405
10101	0.238596
10201	0.242865
10301	0.248328
10401	0.254965
10501	0.263621
10601	0.261818
10701	0.274417
10801	0.272946
10901	0.279434
11001	0.28821
11101	0.292327
11201	0.297448
11301	0.301413
11401	0.306507
11501	0.313108
11601	0.322264
11701	0.331253
11801	0.330332
11901	0.343929
12001	0.354204
12101	0.350988
12201	0.356959
12301	0.362727
12401	0.371634
12501	0.378877
12601	0.387432
12701	0.38903
12801	0.396997
12901	0.402902

13001	0.412632
13101	0.414524
13201	0.419921
13301	0.42725
13401	0.432129
13501	0.463131
13601	0.448017
13701	0.455221
13801	0.468799
13901	0.473549
14001	0.47229
14101	0.48199
14201	0.497067
14301	0.503074
14401	0.509881
14501	0.51028
14601	0.531013
14701	0.528305
14801	0.532981
14901	0.544032
15001	0.552598



2.2 Solución DyV

Para la solución propuesta en el ejercicio siguiendo el patrón DyV hemos usado el código que teníamos de la primera práctica correspondiente al mergesort. Comenzamos presentando el código:

```
#include <iostream>
using namespace std;
#include <ctime>
#include <cstdlib>
#include <climits>
#include <cassert>
#include <chrono>

int contador=0;

double uniforme()
{
 int t = rand();
 double f = ((double)RAND_MAX+1.0);
 return (double)t/f;
}

inline static void CuentaIntercambiosDYV(int T[], int num_elem);

static void mergesort_lims(int T[], int inicial, int fin);

static void fusion(int T[], int inicial, int fin, int U[], int V[]);

void CuentaIntercambiosDYV(int T[], int num_elem)
{
  contador=0;
  mergesort_lims(T, 0, num_elem);
}

static void mergesort_lims(int T[], int inicial, int fin)
{
    int k = (fin - inicial)/2;

    int * U = new int [k - inicial +1];
    assert(U);
    int l, l2;
    for (l = 0, l2 = inicial; l < k; l++, l2++)
                U[l] = T[l2];
    U[l] = INT_MAX;

    int * V = new int [fin - k+1];
    assert(V);
    for (l = 0, l2 = k; l < fin - k; l++, l2++)
                V[l] = T[l2];
    V[l] = INT_MAX;
```

```
    if(k!=0)
    {
     mergesort_lims(U, 0, k);
    }
    if(fin>1)
     mergesort_lims(V, 0, fin - k);
    fusion(T, inicial, fin, U, V);
    delete [] U;
    delete [] V;
}


static void fusion(int T[], int inicial, int fin, int U[], int V[])
{
  int j = 0;
  int k = 0;
  for (int i = inicial; i < fin; i++)
    {
      if (U[j] <= V[k]) {
          T[i] = U[j];
          j++;
      }
      else{
                  T[i] = V[k];
          k++;
            contador+=((fin - inicial)/2 -inicial-j);

      };
    };
}

using namespace std::chrono;

int main(int argc, char * argv[])
{
  high_resolution_clock::time_point t1, t2;

  if (argc != 2)
    {
      cerr << "Formato " << argv[0] << " <num_elem>" << endl;
      return -1;
    }

  int n = atoi(argv[1]);

  int * T = new int[n];
  assert(T);

  srand(time(0));

  for (int j=0; j<n; j++) T[j]=j;
  for (int j=n-1; j>0; j--) {
```

```
    double u=uniforme();
    int k=(int)(j*u);
    int tmp=T[j];
    T[j]=T[k];
    T[k]=tmp;
  }

  int res2=CuentaIntercambios(T,n);
  t1=high_resolution_clock::now();
  CuentaIntercambiosDYV(T,n);
  t2=high_resolution_clock::now();
  duration<double> transcurrido = duration_cast<duration<double> >(t2-t1);
  cout << n << " " << transcurrido.count() << endl;


}
```

Este algoritmo sigue el patrón de división de vectores utilizado en mergesort. Cuando se producen las comprobaciones en la función de fusión utilizamos el else (el cual nos asegura las condiciones del problema) para aumentar el contador k-inicial-j veces contando con ello todos los intercambios correspondientes.

La eficiencia del algoritmo como se puede observar mediante la suma al cuadrado de los residuos es nlogarítmica:
Logarítmica = 0.908574
nlogarítmica = 0.00384006

Presentamos aquí las gráficas y las tablas de datos:

Datos:
-**Tabla y gŕafica de Nacho(Toshiba,Linux):**

Tamaño	Tiempo
1	1.52e-06
5001	0.00178624
10001	0.00396147
15001	0.00604542
20001	0.00835189
25001	0.00742913
30001	0.00865374
35001	0.0113204
40001	0.0122255
45001	0.0134728
50001	0.0156252
55001	0.0170832
60001	0.017964

65001	0.0197751
70001	0.0213026
75001	0.0227894
80001	0.0244177
85001	0.0261721
90001	0.0280973
95001	0.0325655
100001	0.030292
105001	0.0322182
110001	0.0336827
115001	0.034326
120001	0.0363853
125001	0.037599
130001	0.0393026
135001	0.0412435
140001	0.0427228
145001	0.0445968
150001	0.0472664
155001	0.0487102
160001	0.0538634
165001	0.0520374
170001	0.0540296
175001	0.0551591
180001	0.0574901
185001	0.0620998
190001	0.06031
195001	0.0604362
200001	0.0618934
205001	0.070414
210001	0.0643304
215001	0.0660331
220001	0.0682822
225001	0.0713701
230001	0.0766251
235001	0.0755059
240001	0.0740689
245001	0.0754362

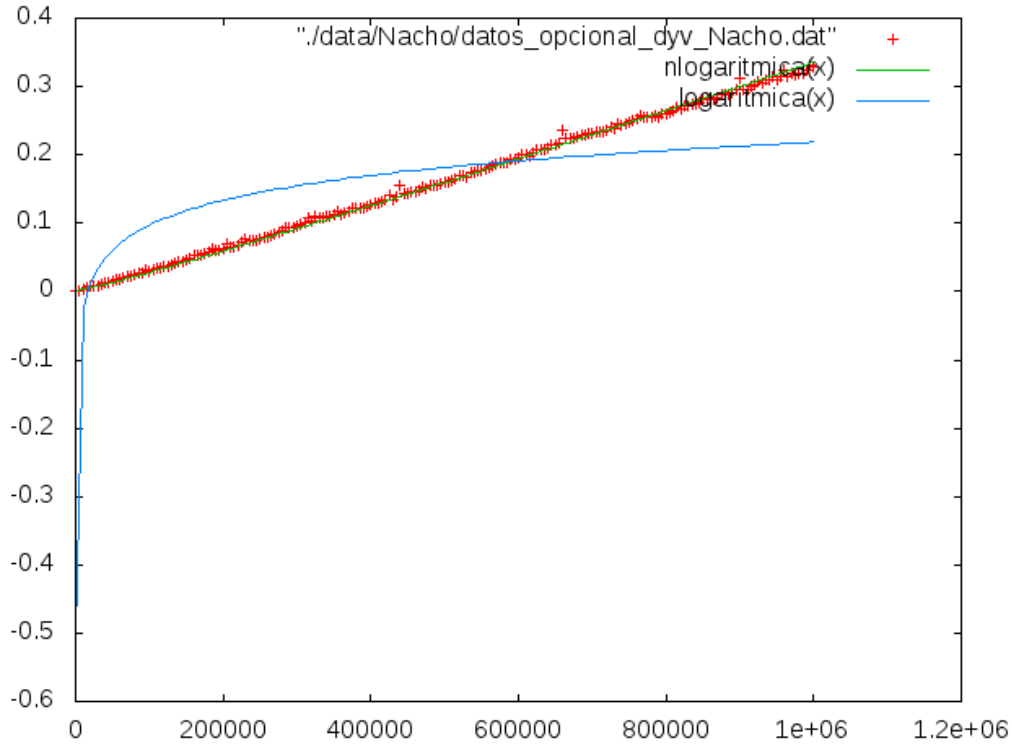
250001	0.0773049
255001	0.0782141
260001	0.0800031
265001	0.0818801
270001	0.0834103
275001	0.0875893
280001	0.0877711
285001	0.0924446
290001	0.0941417
295001	0.0927143
300001	0.0948692
305001	0.0991654
310001	0.100214
315001	0.107412
320001	0.103675
325001	0.109461
330001	0.107742
335001	0.107128
340001	0.110156
345001	0.109832
350001	0.113444
355001	0.118424
360001	0.113623
365001	0.115789
370001	0.118059
375001	0.122402
380001	0.121662
385001	0.121773
390001	0.123248
395001	0.123865
400001	0.126165
405001	0.129056
410001	0.129309
415001	0.131924
420001	0.133366
425001	0.140263
430001	0.13504

435001	0.138679
440001	0.154504
445001	0.143411
450001	0.144196
455001	0.145027
460001	0.146703
465001	0.147377
470001	0.152161
475001	0.150294
480001	0.155973
485001	0.15618
490001	0.154404
495001	0.158231
500001	0.159982
505001	0.159509
510001	0.161626
515001	0.16387
520001	0.169039
525001	0.169102
530001	0.16765
535001	0.174013
540001	0.173966
545001	0.177329
550001	0.176997
555001	0.179374
560001	0.181399
565001	0.183601
570001	0.186204
575001	0.189047
580001	0.189047
585001	0.189682
590001	0.192862
595001	0.193467
600001	0.196609
605001	0.199662
610001	0.200538
615001	0.199139

620001	0.203312
625001	0.207983
630001	0.206874
635001	0.208349
640001	0.21076
645001	0.214727
650001	0.215014
655001	0.216184
660001	0.236536
665001	0.22318
670001	0.223943
675001	0.224316
680001	0.225834
685001	0.228418
690001	0.229855
695001	0.230883
700001	0.231719
705001	0.234823
710001	0.234069
715001	0.234167
720001	0.236557
725001	0.239791
730001	0.238669
735001	0.245259
740001	0.242142
745001	0.246215
750001	0.246875
755001	0.251329
760001	0.252033
765001	0.257582
770001	0.254011
775001	0.254437
780001	0.256029
785001	0.257963
790001	0.254748
795001	0.258895
800001	0.260348

805001	0.261524
810001	0.264108
815001	0.268604
820001	0.266589
825001	0.271645
830001	0.270657
835001	0.273189
840001	0.273804
845001	0.275691
850001	0.280157
855001	0.28012
860001	0.282497
865001	0.281139
870001	0.284164
875001	0.288476
880001	0.288496
885001	0.289213
890001	0.290814
895001	0.296232
900001	0.312298
905001	0.295998
910001	0.29611
915001	0.30123
920001	0.30323
925001	0.307589
930001	0.30542
935001	0.309259
940001	0.310051
945001	0.315484
950001	0.310329
955001	0.315121
960001	0.324399
965001	0.314697
970001	0.318953
975001	0.317691
980001	0.319463
985001	0.31901

990001	0.324368
995001	0.332126
1000001	0.327853



-**<u>Tabla y gŕafica de Luis(Fujitsu,Linux):</u>**

Tamaño	Tiempo
1	3,04E-003
5001	0.00280435
10001	0.0069446
15001	0.00824895
20001	0.0108325
25001	0.0132699
30001	0.0156118
35001	0.0164159
40001	0.0172423
45001	0.0186433
50001	0.0192679
55001	0.0201119
60001	0.021087
65001	0.0225583
70001	0.045376

75001	0.0390957
80001	0.0359109
85001	0.0348029
90001	0.0327471
95001	0.033733
100001	0.0381383
105001	0.0380952
110001	0.0389056
115001	0.0406193
120001	0.0472736
125001	0.0651871
130001	0.0536897
135001	0.0676155
140001	0.0557147
145001	0.054252
150001	0.0608311
155001	0.0565449
160001	0.0575284
165001	0.0918378
170001	0.105408
175001	0.0755219
180001	0.104099
185001	0.0761332
190001	0.0698
195001	0.0701042
200001	0.11762
205001	0.129058
210001	0.13035
215001	0.0783772
220001	0.0792703
225001	0.0833444
230001	0.124107
235001	0.128791
240001	0.147042
245001	0.146374
250001	0.148595
255001	0.0986113

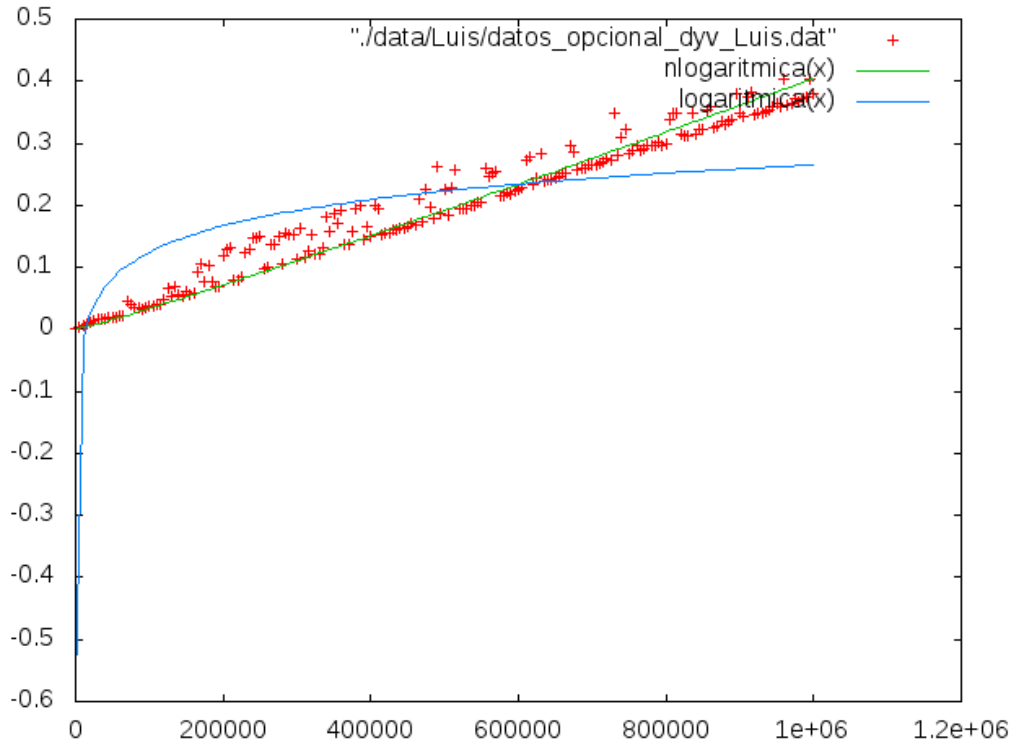
260001	0.100257
265001	0.136372
270001	0.137991
275001	0.150792
280001	0.105603
285001	0.155201
290001	0.151629
295001	0.152823
300001	0.112727
305001	0.162994
310001	0.114891
315001	0.126003
320001	0.151405
325001	0.119961
330001	0.121361
335001	0.130317
340001	0.181025
345001	0.156673
350001	0.186506
355001	0.171599
360001	0.190435
365001	0.13639
370001	0.137781
375001	0.15649
380001	0.193687
385001	0.199969
390001	0.143769
395001	0.165829
400001	0.149944
405001	0.199694
410001	0.194717
415001	0.151718
420001	0.155418
425001	0.156163
430001	0.159047
435001	0.161509
440001	0.162391

445001	0.163272
450001	0.164994
455001	0.169483
460001	0.168687
465001	0.209552
470001	0.172578
475001	0.226241
480001	0.195924
485001	0.178435
490001	0.261104
495001	0.186457
500001	0.22551
505001	0.184894
510001	0.22741
515001	0.257362
520001	0.194231
525001	0.193285
530001	0.194434
535001	0.19851
540001	0.19935
545001	0.204182
550001	0.205122
555001	0.259059
560001	0.245471
565001	0.251672
570001	0.255495
575001	0.215638
580001	0.216219
585001	0.220704
590001	0.2191
595001	0.222031
600001	0.225588
605001	0.22898
610001	0.273437
615001	0.278707
620001	0.233355
625001	0.242923

630001	0.28195
635001	0.23874
640001	0.241386
645001	0.242577
650001	0.243962
655001	0.246593
660001	0.251092
665001	0.251241
670001	0.297444
675001	0.28587
680001	0.257133
685001	0.259394
690001	0.260211
695001	0.2657
700001	0.264693
705001	0.265738
710001	0.268067
715001	0.269005
720001	0.274254
725001	0.272066
730001	0.347363
735001	0.279252
740001	0.310201
745001	0.321718
750001	0.283996
755001	0.287998
760001	0.295435
765001	0.288619
770001	0.291502
775001	0.295397
780001	0.29531
785001	0.296313
790001	0.302547
795001	0.295799
800001	0.299382
805001	0.338932
810001	0.348089

815001	0.347553
820001	0.313523
825001	0.310732
830001	0.311211
835001	0.347724
840001	0.315434
845001	0.323328
850001	0.322152
855001	0.353386
860001	0.360002
865001	0.325699
870001	0.327177
875001	0.335287
880001	0.330191
885001	0.335256
890001	0.338934
895001	0.380881
900001	0.347482
905001	0.342193
910001	0.373334
915001	0.382416
920001	0.344551
925001	0.347968
930001	0.348247
935001	0.351615
940001	0.353225
945001	0.358573
950001	0.363364
955001	0.359023
960001	0.402944
965001	0.36248
970001	0.3654
975001	0.372761
980001	0.366989
985001	0.372672
990001	0.375118
995001	0.402279

1000001	0.378636



-<u>Tabla y gráfica de Miguel(Toshiba,Windows):</u>

Tamaño	Tiempo
1	8.55308e-007
5001	0.00349735
10001	0.00765971
15001	0.0108782
20001	0.0143816
25001	0.0182685
30001	0.0218275
35001	0.0258953
40001	0.0299785
45001	0.0337962
50001	0.0367564
55001	0.0404997
60001	0.043595
65001	0.0478472
70001	0.0528713
75001	0.0550356
80001	0.058982

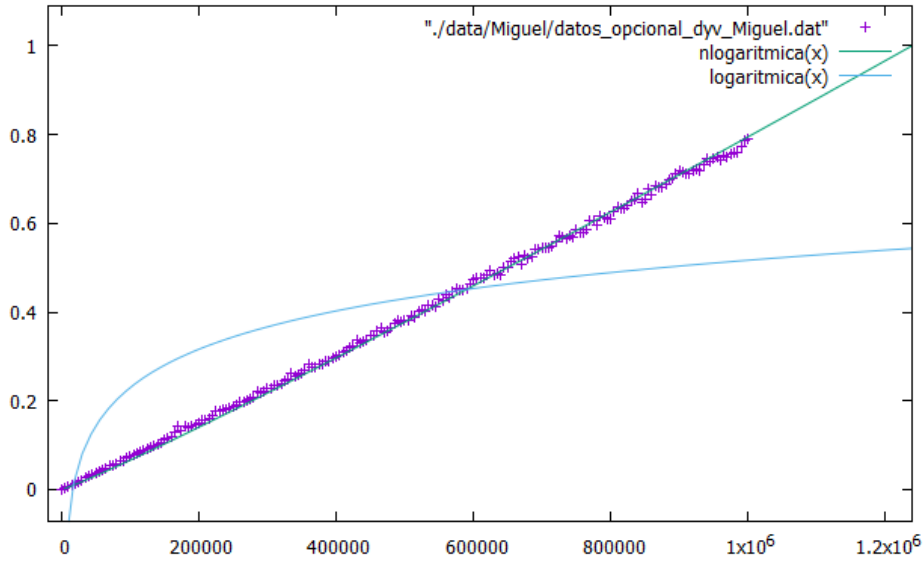
85001	0.0639214
90001	0.0661243
95001	0.0708011
100001	0.0737725
105001	0.0789992
110001	0.0810768
115001	0.0844694
120001	0.0888477
125001	0.0920474
130001	0.0958454
135001	0.0991995
140001	0.10367
145001	0.107061
150001	0.111551
155001	0.115136
160001	0.118903
165001	0.130023
170001	0.143892
175001	0.134003
180001	0.144278
185001	0.140283
190001	0.141207
195001	0.145988
200001	0.149755
205001	0.156545
210001	0.156303
215001	0.160464
220001	0.166272
225001	0.178553
230001	0.178112
235001	0.181615
240001	0.180264
245001	0.184917
250001	0.18764
255001	0.191191
260001	0.19846
265001	0.19698

270001	0.202509
275001	0.205709
280001	0.208353
285001	0.221201
290001	0.217049
295001	0.221819
300001	0.22738
305001	0.229678
310001	0.233531
315001	0.236208
320001	0.238941
325001	0.244691
330001	0.248091
335001	0.260874
340001	0.256884
345001	0.258031
350001	0.261816
355001	0.268664
360001	0.28251
365001	0.276469
370001	0.276829
375001	0.282306
380001	0.284076
385001	0.288299
390001	0.290963
395001	0.296206
400001	0.300259
405001	0.303551
410001	0.30927
415001	0.312063
420001	0.319675
425001	0.322508
430001	0.335911
435001	0.329571
440001	0.335081
445001	0.336436
450001	0.348429

455001	0.347103
460001	0.358713
465001	0.365992
470001	0.354215
475001	0.359277
480001	0.36305
485001	0.376222
490001	0.380135
495001	0.378681
500001	0.38175
505001	0.383295
510001	0.392552
515001	0.388876
520001	0.401857
525001	0.404249
530001	0.400514
535001	0.416498
540001	0.414288
545001	0.411765
550001	0.430316
555001	0.424642
560001	0.438699
565001	0.432928
570001	0.446737
575001	0.452414
580001	0.448518
585001	0.448818
590001	0.452927
595001	0.463361
600001	0.473062
605001	0.478444
610001	0.477593
615001	0.476881
620001	0.482338
625001	0.492532
630001	0.482711
635001	0.487857

640001	0.483684
645001	0.500865
650001	0.499755
655001	0.515302
660001	0.522555
665001	0.524276
670001	0.508109
675001	0.528269
680001	0.521498
685001	0.525559
690001	0.542556
695001	0.542982
700001	0.544008
705001	0.544673
710001	0.545866
715001	0.54837
720001	0.558782
725001	0.571221
730001	0.570114
735001	0.566869
740001	0.572171
745001	0.570528
750001	0.586457
755001	0.580538
760001	0.579991
765001	0.584297
770001	0.605928
775001	0.606098
780001	0.597183
785001	0.616067
790001	0.614839
795001	0.609111
800001	0.609971
805001	0.627066
810001	0.635816
815001	0.632691
820001	0.63545

825001	0.639422
830001	0.649567
835001	0.652498
840001	0.668774
845001	0.648244
850001	0.653525
855001	0.677752
860001	0.66385
865001	0.683829
870001	0.682564
875001	0.681589
880001	0.688345
885001	0.698503
890001	0.703486
895001	0.710625
900001	0.71924
905001	0.714923
910001	0.713323
915001	0.710953
920001	0.71858
925001	0.722813
930001	0.717992
935001	0.733727
940001	0.744663
945001	0.738258
950001	0.746976
955001	0.748957
960001	0.744064
965001	0.751436
970001	0.750981
975001	0.756016
980001	0.760509
985001	0.760429
990001	0.774926
995001	0.787202
1000001	0.790414



-**Tabla y gŕafica de Diego(MacBook Pro,MacOS El Capitán):**

Tamaño	Tiempo
1	1,86E-003
5001	0.00281619
10001	0.0101761
15001	0.0125123
20001	0.0126021
25001	0.0180162
30001	0.0287942
35001	0.0312425
40001	0.0250505
45001	0.0401589
50001	0.0386131
55001	0.0516536
60001	0.0491155
65001	0.0426887
70001	0.0510938
75001	0.0572343
80001	0.0674531
85001	0.067953
90001	0.0710223
95001	0.072934
100001	0.0848613
105001	0.0923425
110001	0.0884513

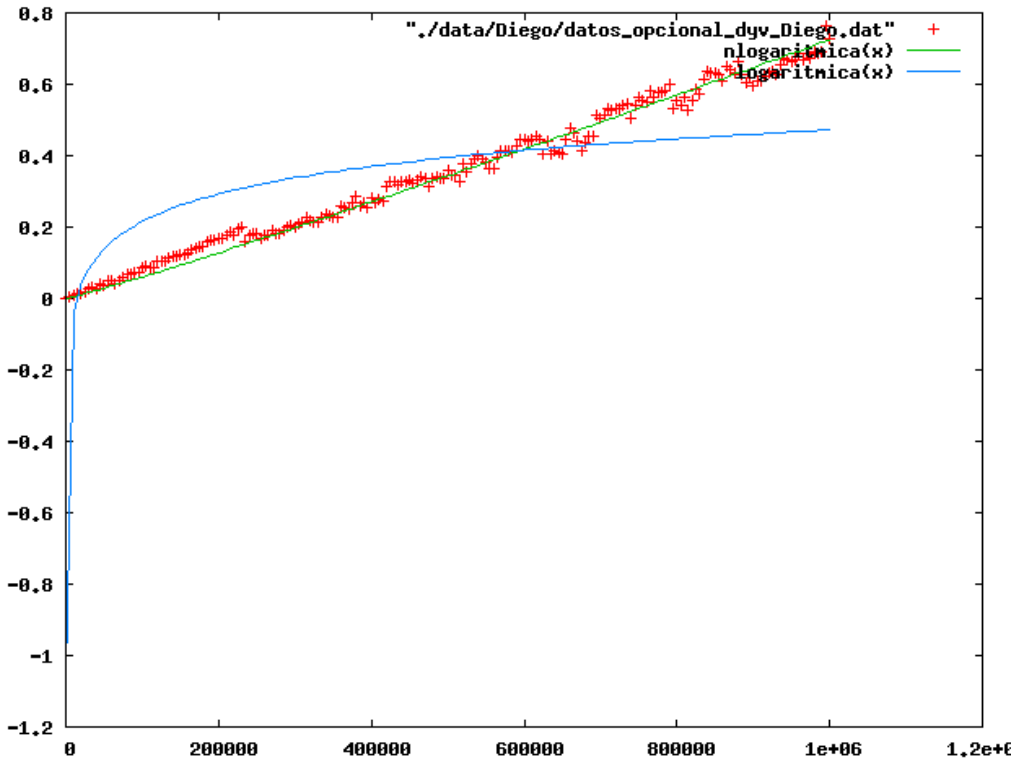
115001	0.0875315
120001	0.105349
125001	0.105917
130001	0.103948
135001	0.115772
140001	0.117792
145001	0.120277
150001	0.122679
155001	0.124424
160001	0.129239
165001	0.135987
170001	0.142613
175001	0.1475
180001	0.145177
185001	0.158695
190001	0.164042
195001	0.163805
200001	0.168574
205001	0.16876
210001	0.175025
215001	0.186127
220001	0.176791
225001	0.197478
230001	0.201662
235001	0.160103
240001	0.1785
245001	0.182863
250001	0.181985
255001	0.168385
260001	0.178131
265001	0.175313
270001	0.188719
275001	0.183059
280001	0.183172
285001	0.190792
290001	0.199971
295001	0.202608

300001	0.200871
305001	0.207142
310001	0.214463
315001	0.227032
320001	0.216723
325001	0.215533
330001	0.215698
335001	0.2294
340001	0.23461
345001	0.231553
350001	0.228629
355001	0.227771
360001	0.25953
365001	0.252655
370001	0.249947
375001	0.268686
380001	0.284206
385001	0.259741
390001	0.268153
395001	0.255111
400001	0.280866
405001	0.268103
410001	0.276724
415001	0.274117
420001	0.315225
425001	0.325629
430001	0.325484
435001	0.31735
440001	0.325634
445001	0.327139
450001	0.333365
455001	0.322085
460001	0.331652
465001	0.339737
470001	0.334102
475001	0.311402
480001	0.336021

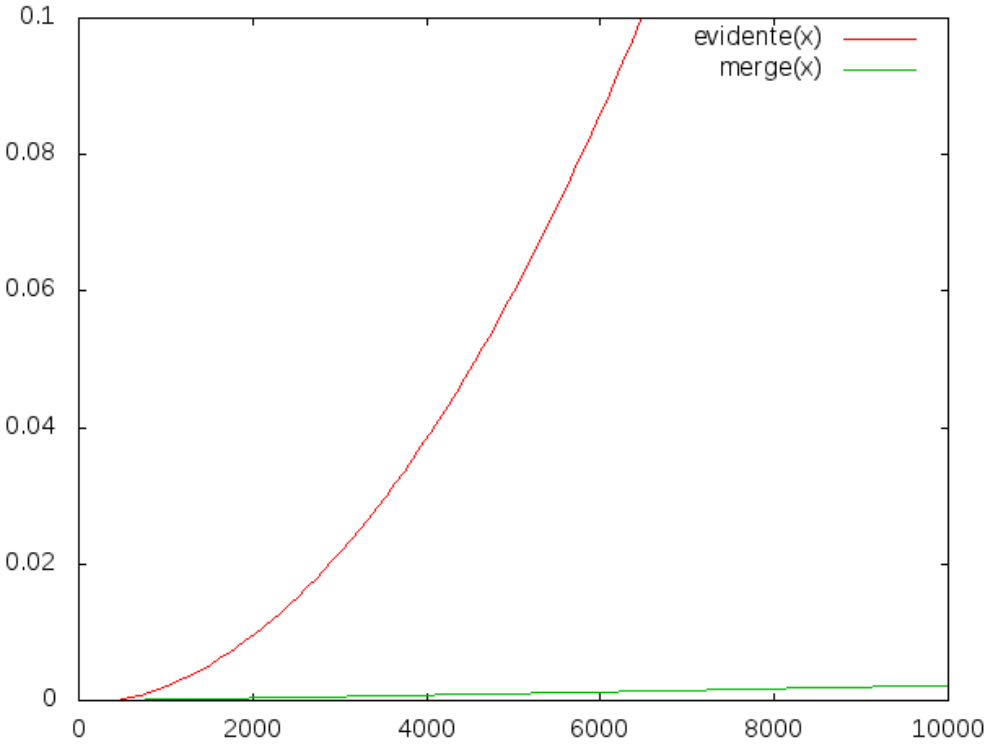
485001	0.339398
490001	0.336809
495001	0.337852
500001	0.356968
505001	0.347069
510001	0.345944
515001	0.32835
520001	0.378447
525001	0.352807
530001	0.378042
535001	0.391851
540001	0.398031
545001	0.389124
550001	0.37992
555001	0.361911
560001	0.365587
565001	0.393513
570001	0.413972
575001	0.412435
580001	0.41378
585001	0.41
590001	0.427851
595001	0.444138
600001	0.443293
605001	0.442345
610001	0.445146
615001	0.45336
620001	0.443207
625001	0.406292
630001	0.439386
635001	0.405387
640001	0.413441
645001	0.409719
650001	0.404946
655001	0.444852
660001	0.477099
665001	0.464672

670001	0.439567
675001	0.415062
680001	0.437883
685001	0.453412
690001	0.454095
695001	0.511882
700001	0.503803
705001	0.512721
710001	0.532884
715001	0.527243
720001	0.533729
725001	0.530581
730001	0.539477
735001	0.546544
740001	0.50437
745001	0.542037
750001	0.565071
755001	0.556593
760001	0.550815
765001	0.581459
770001	5,65E+002
775001	0.578064
780001	0.578018
785001	0.581167
790001	0.59892
795001	0.531243
800001	0.55248
805001	0.539957
810001	0.561719
815001	0.529154
820001	0.553896
825001	0.587717
830001	0.574999
835001	0.615626
840001	0.636929
845001	0.63313
850001	0.630457

855001	0.625494
860001	0.607557
865001	0.650704
870001	0.639974
875001	0.633495
880001	0.661524
885001	0.628491
890001	0.603352
895001	0.620204
900001	0.594821
905001	0.607042
910001	0.610657
915001	0.622538
920001	0.633575
925001	0.634156
930001	0.626981
935001	0.656219
940001	0.674409
945001	0.667876
950001	0.664974
955001	0.666568
960001	0.684337
965001	0.66948
970001	0.685572
975001	0.671941
980001	0.692037
985001	0.686069
990001	0.690571
995001	0.763408
1000001	0.729304



2.3 Comparación entre algoritmos



Como observamos en la gráfica con las funciones que ajustan a cada uno de los algoritmos el algoritmo de mergesort modificado es mucho mas eficiente que el evidente. Esto se produce porque la eficiencia del algoritmo evidente es cuadrática mientras que la del algoritmo modificado de mergesort es nlogarítmica.