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THE REAL DISTRIBUTION OF MINIMAL PUZZLES

Goto page [Previous](#) [1](#), [2](#), [3](#) ... , [39](#), [40](#), [41](#) [Next](#)



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Author

Message

eleven

Posted: Sat Oct 17, 2009 12:07 pm Post subject:



Joined: 10 Feb 2008
Posts: 541

Its finished. The 3Gh dual core can do about 7000 grids (read from a file) per hour on one core with your racing program.

Its strange, that the error percentage is higher with yours, maybe you found rare clusters. Lets see, what we get, when we put them together.

204899 grids, 369 32 clues

jct[0] = 204734

jct[1] = 86

jct[2] = 37

jct[3] = 11

jct[4] = 13

jct[5] = 6

jct[6] = 5

jct[7] = 1

jct[8] = 1

jct[9] = 3

jct[11] = 2

jct[1000+] = 0

Estimated mean number of proper minimal 32s per grid = 3.947339e+10

Estimated relative error = 10.38%

I will calculate the SER's tomorrow.

Here are the puzzles:

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100000780057080036000000005270000018300000000819000360500047091000908650000061073
group 2
103000700050109006090070104200000003309701000785204900000907008000000000900845307
group 1
000406780007100206000000010000000350500000072039705060005267800780041500002508000
group 1
000456000000109006000070500030005061016003905080600020370004050040030000802507403
group 1
020056780007189006600000504000000300034021078700008002000007105000063020900200800
group 1
020006709000100036690072541010700000500024100074590300002000000740065900060000000
020000709000100036690072541010708000500024100074590300002007000040005900960000000
020000709000100036690072541010700000530024100074590300002000000740065900060000000
020000709000100036690072541010700000500024100074590300002900000740005903060000000
group 4
103000700000009030098000145001067000500201407000040610304090070005370920000008300
0030007094000000030698000145041060000500201090709040610304000070005370900000008300
0030007094000000030698000145041060000500201090700040610304000070005370900900008300
0030007094000000030698000145001060000500201490709040610304000070005370900000008300
0030007094000000030698000145001060000500201490700040610304000070005370900900008300
group 5
100450700007089000090000000061890000500210060870605020010900052002000300940020071
group 1
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100006700057000000698700000200300400014508900085204001030000800060005003801003605
100006000057000000698702500000000400310508900985204001030000000060005103801003605
100006000057000000698700500200300400310508900085204001030000000060005103801003605
100006000057000000698700000200300400310508900085204301030000800060005003801003605
100006000057000000698700000200300400014508900085204301030000800060005003801003605

10000600005700000069870000000300400310508900085204301030000800060005003841003605
10000600005700000069870000000300400014508900085204301030000800060005003841003605
10000600005700000069870000000090400014508900085204301030000800060005003841003605
100006000050000000698700000200300400310508900085204301030000800060005003841003605
100006000050000000698700000200300400014508900085204301030000800060005003841003605
group 11
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group 1
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group 1
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12000600000700000086927004000150006008532107470006850001000000000004000908012650
group 2
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100050009050000030809073015008740093005001072700002000000000921030000008980010067
100050009000100030809073015008740093005000072700002000500000921030000008980010067
100050009000000030809073015008740093005001072700002000500000921030000008980010067
group 4
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group 1
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group 1
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100406089407109036000000100200004300304067090000000000006703020740020000002841600
group 2
103406709007109206009370100200500010005003002000000600374600508502000400080000000
group 1
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120050080400180036809302510000500648005200190004000050006020000700613000030000000
group 2
103006700000000030860023105206034090010002004008601302002067000680040000004008000
103006700000000030800023145206034090010002004008601302002067000680040000004008000
103006700000000030800023105206034091000002004008601302502067000680040000004008000
100406000007100030800023105206034001010002004008600302002067000680040900700008000
group 4
1200500090070090000069700045005030000000000001000578002000010024701902853002300017
group 1
003400089007009000000020004014500800700930001930014500000201070501000300072300908
group 1
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020006780057100030800000150200340900000801023030070500310200890002000000690010070
group 2
123056089000100006000032000210060970086007001700010000500000093600300000030070652
1230560890001000060000320002100609000860070017000100005000000936003000007030070652
1230560890001000060000320002100009000860070017000100005000200936003000007030070652
123056089000100006000032000010060970086007001700210000500000093600300000030070652
123056089000100006000032000010060900086007001700210000500000093600300007030070652
123056089000100006000032000010000970086007001700210000500020093600300000030070652
1230560890001000060000320000100009000860070017002100005000200936003000007030070652
123056080000100006000032000010000970086007001700210000570020093600300000030070652
group 9
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group 1
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02005000940010020000023001400031500057406000000700000300670092760090100940500073
020050009000100200000230014000315000574060001000740000300670092760090000940500073
02005000900010020000023001400031500057406000000740000300670092760090100940500073
group 4
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group 1
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00000600945710903000032010500000060064007000208160200031000450050000003060730401
group 2
000456709000000200896300500289003005300095020600040003538904000040000300902000000
000456709000000200896300500289003005300095000600240003538904000040000300902000000
000456709000000200896300500289003005300005020600040903538904000040000300902000000
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000456009000000200896300500289703005300095000600040003538904002040000300902000000
000456009000000200896300500289703005300095000600040903538904002040000300902000000
group 9

020006009050180030800002050000030007600207300700001025070610090560000070918700003
000006009050180030800002050200030007600207300700001025070610090560000070918700003
group 2
000000709407000230006700104205974003009005000741032005504000000600001597000008000
000000009407000230006700104205970003009005402741030005504000000600041597000008000
group 2
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120400700057009200006000000010903807039807002700040003000000908080094300000308405
group 2
100406780000180230000000104216804000030607000700003040300000000000008390890300462
100406780000180230000000104210804000030607000700003640300000000000008390890300462
100406780000180230000000104210804000030607000700003040300060000000008390890300462
group 3
000000009007109206900207050008510400001072568000004012000000000012300005809025600
000000009007109206900207050008510400001072568000004012000000000012300000809725600
group 2
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group 1
000006009400109003600020010201064090794008006860200000002005008008900070940002050
group 1
003400000000109200009320504040000600800000125001002408090001000014638902008200300
group 1
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group 1
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group 1
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group 1
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000000080000100200080302015076508000030204090000030008062010870090607100710023006
group 2
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group 1
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003400000450100000680003050200805931500390028008000540360900010000030002092500000
group 2
000000780450009000080002045200091000090000020701203008570014800000900500912500074
000000000450109000080702045200091007090000020701203008570014800800000000912508004
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group 3
003006780007180063000030000201040008390620400000300092700000020045000006002860504
group 1
000450709007009200609700154008001400060940000010208305006800020000020000802000907
group 1
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103406080050080000000230000005000910036000842910002007009608120060900308000020090
100406080050089000600230000005000910036000802910002007309600120060900308000020090
100406080050089000600230000005000910036000802910002007009608120060900308000020090
100406000050089000600230000005000910036000802910002037009608120060900308000020090
group 5
120050000450180260008070004246001800700800020080000000070005040010340670000010305
120060000450180260008070000246031800700800020080000000070005040010340670000010305
group 2
120400709400009000090270014265010000040560007700000000010300800032640900900001030
120400709400009000000270014265010000049560007700000000010300800032640900900001030
120400709400009000000270014265010000049560007700000000010090800032640900900001030
group 3
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group 1
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group 1
003456080000009203098002405085907000370500000004030000500000000049600000801745900
00045608900700920309000240508590700037050009000403000000000000749600000801745000
group 2
120000000057000000096037104000960030009070406001324090000000015700690300005013600
group 1
023450780000089203000070400270098000005040070960700508540000390002000800030004000
group 1
120056089050009020600020104200908410000000072000000800000700060006290007740063001
group 1

[Back to top](#)



eleven

Posted: Sat Oct 17, 2009 12:27 pm Post subject:



Joined: 10 Feb 2008
Posts: 541

SER ratings for the puzzles above:
369 puzzles, sum 2540, min 1.2, max 9, average 6.88347

SER for the
11 clusters: 22 puzzles, sum 126.1, min 1.5, max 8.3, average 5.73182
9 clusters: 27 puzzles, sum 139.9, min 1.5, max 8.5, average 5.18148

[Back to top](#)

[profile](#) [pm](#)

Red Ed

Posted: Sat Oct 17, 2009 12:57 pm Post subject:

[quote](#)

Joined: 06 Jun 2005
Posts: 815

That'll be it - you've found no very big clusters. You didn't say how you generated the file of random grids from gs's collection; I just wonder if some bias may have crept in.

My jct[] array at the moment is:

Code:

```
jct[ 0 ] = 254120
jct[ 1 ] = 113
jct[ 2 ] = 44
jct[ 3 ] = 18
jct[ 4 ] = 10
jct[ 5 ] = 3
jct[ 6 ] = 4
jct[ 7 ] = 1
jct[ 8 ] = 1
jct[ 9 ] = 2
jct[ 11 ] = 1
jct[ 14 ] = 1
jct[ 15 ] = 1
jct[ 20 ] = 1
jct[ 25 ] = 1
jct[1000+] = 0
```

... giving mean 3.90e10 w. relative error 11.4%.

The pooled estimates from our two experiments are:

- Mean number of proper minimal 32s per grid = 3.9187e10
- Relative error = 7.84%

The big cluster is:

Code:

```
30700040905094007000070352154300000000016000060405002006100000930604010010097000
307000409050940070000703521043200000082016000000400002006100005900604017010090000
307000409050940070000703521043200000080016000009400002006100005900604017010090000
3070004090500400700007035215432000000000160000004000020061000095930604010210090000
307000409050040070000703521543009000000016000060405002006100000930604010010097000
3070004090500400700007035215430090000000160000004000020061000095930604010010097000
307000409050040070000703521043200000002016000060400002006100005930604017010090000
307000409050040070000703521043200000000016000060400002006100005930604017010097000
307000409050040070000703521043009000700016000000405002000100095930604010210090000
307000409050040070000703521043009000700016000000400002006100095930604010210097000
307000400050940070090703521043000006002016000000405002000100000900604017018097000
307000400050940070090703521043000006000016000000480002006100000930604017010097000
307000400050940070000703521543200000700016050100400002006100000930604010010090000
3070004000509400700007035215432000000700016050060400002006100000930604010010090000
3070004000509400700007035215432000000000160000004000020061000095930604010210090000
307000400050940070000703521543000000700016050100400702006100000930604010010090000
307000400050940070000703521543000000700016050060400002006100000930604010010097000
307000400050940070000703521543000000700016050060400002006100000930604010010097000
307000400050940070000703521043200000700016050160400002006100000930604010010090000
30700040005094007000070352104320000002016000060400002006100005930604017010090000
30700040005094007000070352104320000000016000060400002006100005930604017010097000
307000400050940070000703521043000006002016000009405002000100000900604017018097000
```

I've not computed SER or anything on that.

btw, I checked and I'm actually running a quicker processor than I had realised: it's an Athlon 64 X2

3800+, which apparently is a 2GHz thing. Bit of an :oops: then when I said I could get that speed with only 1.4GHz. But on the plus side maybe I should investigate using a better compiler now 😊

btw (again) - there's one obvious speed improvement not yet implemented, and that's to compress each slist entry down to a single 64-bit word, since if SUBSZ=24 then at most 81-SUBSZ-2=55 bits are needed there. Same sort of thing goes for the template lists, too.

[Back to top](#)



eleven

☐ Posted: Sat Oct 17, 2009 2:31 pm Post subject:



Joined: 10 Feb 2008
Posts: 541

Red Ed wrote:

I guess "randomly selected" = decompress each in turn and select with probability 200000/5472730538 ?

Yes, as i posted it [there](#).

[Back to top](#)



Allan Barker

☐ Posted: Sat Oct 17, 2009 9:34 pm Post subject:



Joined: 20 Feb 2008
Posts: 355
Location: Bangkok

Puzzles

While doing some cleanup, I uploaded two additional puzzle files made along with the previous groups of minimal puzzles on my website. These were (again) made using a countdown followed by a directed random walk to find a minimal. The files contain about 1000 34s and 11 35 clue minimals. The files can be found on my data page [here](#).

Rabahola Generator

Seeing that the level of bias in grids generated from my montecar.exe was about equal to those from Antti Ahola's blazing program [here](#), I looked at implementing the B159 method in C. With a little impetus from Paul, and by adding a re-entrant solver, the program generates about 63,000 grids/sec./GHz. or about 125,000 grids/sec. on a 2 GHz. machine. The source and executable can be found [here](#).

It's interesting to reflect on the two approaches. The Monte Carlo method seeks to make every step random, but is forced at some point to make a decision between two states of the grid. The B159 method fills 3 boxes at random after which it is completely deterministic. The equal levels of bias suggest that *any* decision based on the state of the grid leads to some bias.

[Back to top](#)



eleven

☐ Posted: Sun Oct 18, 2009 3:25 am Post subject:



Joined: 10 Feb 2008
Posts: 541

Here are stats for the 31 clue search i had made in parallel. Its not really what i wanted to get 😊

204899 grids, 2716 31's

Estimated mean number of proper minimal 31s per grid = 1.162165e+12

Estimated relative error = 5.98%

Code:

```

jct[ 0 ] = 204050   jct[ 16 ] =      2
jct[ 1 ] =    393   jct[ 17 ] =      2
jct[ 2 ] =    158   jct[ 18 ] =      3
jct[ 3 ] =    100   jct[ 19 ] =      1
jct[ 4 ] =     53   jct[ 20 ] =      1
jct[ 5 ] =     31   jct[ 21 ] =      1
jct[ 6 ] =     26   jct[ 22 ] =      1
jct[ 7 ] =     22   jct[ 23 ] =      2
jct[ 8 ] =      9   jct[ 31 ] =      1
jct[ 9 ] =      8   jct[ 32 ] =      1
jct[ 10 ] =      4   jct[ 33 ] =      1
jct[ 11 ] =      5   jct[ 34 ] =      1
jct[ 12 ] =      2   jct[ 36 ] =      1
jct[ 13 ] =      9   jct[ 37 ] =      1
jct[ 14 ] =      3   jct[ 39 ] =      1

```

```
jct[ 15 ] =      5   jct[ 43 ] =      1
```

SER: min 1.2, max 9.1, average 6.96771

Ok, higher than for the 32's, but explainable with the 6/10% error bounds.

But i quickly can forget the idea, that more clustered puzzles are easier (i love it that all my conjectures are wrong):

Code:

```
SER for clusters:
< 5 : 1221 lines, min 1.5, max 9.1, average 6.93
5-14 : 887 lines, min 1.5, max 9 , average 6.99
15-24 : 323 lines, min 1.5, max 9 , average 7.26
25-34 : 130 lines, min 1.2, max 9 , average 5.83
> 34 : 155 lines, min 2.8, max 9 , average 7.46
```

(SER for RedEds 25 cluster with 32 clues is 7.17)

So in sudoku bulk good need not be cheaper 😊

[Back to top](#)

[profile](#) [pm](#)

Red Ed

Posted: Sun Oct 18, 2009 9:11 am Post subject:

[quote](#)

I don't know; looks like there could be a trend there. How about two more clusters in the 25-34 age, er I mean clue, range:

Cluster size = 30:

```
074801009000000000015003078000006950000475080107309040006004000040607005001530004
074801009000000000015003078000006907000405080157309040006004000040607005001530004
074801009000000000015003078000006900000475080157309040006004000040607005001530004
074801009000000000015003078000006900000405080007389046006004030040607005001530004
004801009090000000015003478008006900000405083007309006006004000040607005001530004
004801009000000000015003478008006900000405083007309006086004000040607005001530004
004801009000000000015003478008006900000405080007309006006004030040607005001530604
004801009000000000015003478000006950000405083007309006006004030040607005001530004
004801009000000000015003078000006900000405080007389046006004030040607005701530004
004801009000000000015003070008006950000405080107309046006104000040607005001530004
004801009000000000015003070008006900000405080157309046006104000040607005001530004
00480100080000000001500307000006957060405080107309046006004000040607005001530004
00480100080000000001500307000006950060475080107309046006004000040607005001530004
00480100080000000001500307000006950060405080007309046006104000040607005701530004
00480100080000000001500307000006907060405080157309046006004000040607005001530004
00480100080000000001500307000006900060475080157309046006004000040607005001530004
00480100080000000001500307000006900060405080157309046006104000040607005001530004
004801000090000000015003478000006900060475083007309000006004000040607805001530004
004801000090000000015003078000006900060475083007309046006004000040607005001530004
004801000090000000015003078000006900060475083007309040006004000040607805001530004
004801000000000000015003078000006957060405080107309046006004000040607005001530004
004801000000000000015003078000006950060475080107309046006004000040607005001530004
004801000000000000015003078000006907060405080157309046006004000040607005001530004
004801000000000000015003078000006900060475080157309046006004000040607005001530004
004801000000000000015003078000006900060475080107309046006004030040607005001530004
004801000000000000015003070008006950060405080107309046006104000040607005001530004
004801000000000000015003070008006900060405080157309046006104000040607005001530004
```

Cluster size = 28:

```
380761509501000008690000000400010007069400100000039080000000005705304806000075040
380761509501000008690000000400010000069407100000039080000000005705304806000075040
380761509071000008690000000400010000069407100000039080000000005705304806000075040
380761509001000008690000000400010000069407100107039000000000005705304806000075040
380761509001000008690000000400010000069407100007039080000000005705304806000075040
38076150900100000869000000040001000006940010310703900000000005705304806000075040
304761509501000008690000000400010007069400100000039080040000005705304806000075000
```

Joined: 06 Jun 2005
Posts: 815

```

30476150950100000869000000040001000706940010000003908000000005705304806000075040
304761509501000008690000000400010000069407100000039080040000005705304806000075000
30476150950100000869000000040001000006940710000003908000000005705304806000075040
304761509501000008690000000000010007069400100100039080040000005705304806000075000
304761509501000008690000000000010000069407100100039080040000005705304806000075000
30476150907100000869000000040001000706940010010003900000000005705304806000075040
304761509071000008690000000400010007069400100000039080040000005705304806000075000
30476150907100000869000000040001000706940010000003908000000005705304806000075040
304761509071000008690000000400010000069407100000039080040000005705304806000075000
30476150907100000869000000040001000006940710000003908000000005705304806000075040
304761509071000008690000000000010007069400100100039080040000005705304806000075000
304761509071000008690000000000010000069407100100039080040000005705304806000075000
30476150900100000869000000040001000706940010007039080040000005705304806000075000
304761509001000008690000000400010007069400100007039080040000005705304806000075000
304761509001000008690000000400010007069400100007039080040000005705304806000075040
30476150900100000869000000040001000006940010310703900000000005705304806000075040
304761509001000008690000000000010007069400100107039080040000005705304806000075000
304761509001000008690000000000010000069407100107039080040000005705304806000075000

```

Just a thought: being in a big cluster is a bit like having lots of 32-clue proper minimal neighbours with the same solution, except that the latter doesn't suffer from the random element which is the choice of the base 24-clue subgrid. So you might be able to observe a better correlation between SER and, say, #proper minimal 32s up to 3 clues away (and with the same solution grid).

Another thought: as this is Denis' thread, should we be making conjectures on the NRCZT rating as well ...

[Back to top](#)



Red Ed

Posted: Sun Oct 18, 2009 1:59 pm Post subject:



Joined: 06 Jun 2005
Posts: 815

I've done as much as I want to on 32s now:

Code:

```

> rbind(x,ct)
      [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12]
[,13] [,14]
x      0     1     2     3     4     5     6     7     8     9     10    11
12     14
ct 381844 165   76   24   15   5     5     1     1     2     1     2
      1     1
      [,15] [,16] [,17] [,18] [,19]
x      15    20    25    28    30
ct      1     1     1     1     1
> sum(x*ct)/sum(ct)*choose(81,24)/choose(32,24)
[1] 40895532054
> sqrt((sum(ct)*sum(x*x*ct)/sum(x*ct)^2-1)/(sum(ct)-1))
[1] 0.1003534
>

```

So that's mean 4.0896e10 with relative error 10.0%.

Tomorrow perhaps I'll run SE against the 713 proper minimal 32s saved off during the course of the experiment.

[Back to top](#)



denis_berthier

Posted: Sun Oct 18, 2009 11:12 pm Post subject:



Joined: 19 Jun 2007
Posts: 943
Location: Paris, France

Pisaacson wrote:

denis_berthier wrote:

How can the bb-solver be used as an independent solver:

- puzzles (file or stream) as input,
- stream of solution grids as output

You can download and compile the base source code from

<http://sites.google.com/site/bbsudokufiles>

I tried but I can't compile it on my Mac.
In fact, I meant "how can your improved version of it be used as an independent solver?"

[Back to top](#)

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denis_berthier

Posted: Sun Oct 18, 2009 11:16 pm Post subject:

[quote](#)

Joined: 19 Jun 2007
Posts: 943
Location: Paris, France

Red Ed,

I'm wondering about your estimate of the error in your algorithm.
As you admitted, the puzzles in your samples are correlated. How then do you compute the standard deviation?

[Back to top](#)

[profile](#) [pm](#) [www](#)

Red Ed

Posted: Sun Oct 18, 2009 11:24 pm Post subject:

[quote](#)

The subsets method is done like [this](#) as justified [here](#).

Joined: 06 Jun 2005
Posts: 815

I'll write up something similar for the supersets method.

[Back to top](#)

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denis_berthier

Posted: Sun Oct 18, 2009 11:36 pm Post subject:

[quote](#)

Joined: 19 Jun 2007
Posts: 943
Location: Paris, France

Allan Barker wrote:

I uploaded two additional puzzle files made along with the previous groups of minimal puzzles on my website. These were (again) made using a countdown followed by a directed random walk to find a minimal. The files contain about 1000 34s and 11 35 clue minimals. The files can be found on my data page [here](#).

Hi **Allan,**

Interesting data. I think we should consider your algorithm more closely for the large n-clue puzzles. I have a problem with your 34s file. I can't read the file after the 385th puzzle.

Could you check that there is no hidden sign or whatever in the file? I don't see how that could be, but I tried to download it several times and I have the same problem every time.

I've also thought of a way of testing your algorithm for bias. Now that we know precisely the mean SER for every n in [22, 30] (I'll soon publish my results, based on ~ 1,300,000 puzzles): if you could generate 1000 puzzles with 25, 26 or 27 clues, we could compare.

[Back to top](#)

[profile](#) [pm](#) [www](#)

Red Ed

Posted: Mon Oct 19, 2009 12:00 am Post subject:

[quote](#)

Joined: 06 Jun 2005
Posts: 815

If the data's available then it might be advisable, for each number of clues, n, to also perform a distribution equality test on the full range of SER values seen in Denis' and Allan's sample data. Even if you're only making conjectures about the mean, it might pay to understand how the constituent parts affect the average.

[Back to top](#)

[profile](#) [pm](#)

denis_berthier

Posted: Mon Oct 19, 2009 1:18 am Post subject:

[quote](#)

Joined: 19 Jun 2007
Posts: 943
Location: Paris, France

Red Ed,

For a correlated collection, the standard deviation can be a very bad estimate of the precision of the mean. Example: take 1 billion puzzles, all the same. For any random variable X, $sd(X) = 0$.

[Back to top](#)

[profile](#) [pm](#) [www](#)

Red Ed

Posted: Mon Oct 19, 2009 1:27 am Post subject:

[quote](#)

Correct. But you'll see when you read it in detail that the standard error calculation for the subsets method takes that into account (the supersets calculation works on the same principles - as you can verify from the

Joined: 06 Jun 2005

Posts: 815 formulae posted above).

[Back to top](#)



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[General/puzzle](#)

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Goto page [Previous](#) [1](#), [2](#), [3](#) ... , [39](#), [40](#), [41](#) [Next](#)

Page 40 of 41

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