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The Uniqueness of Unique Identifiers

Status of this Memo

This memo provides information for the Internet community. It does not specify an Internet standard. Distribution of this memo is unlimited.

Abstract

This RFC provides information that may be useful when selecting a method to use for assigning unique identifiers to people.

1. The Issue

Computer systems require a way to identify the people associated with them. These identifiers have been called "user names" or "account names." The identifers are typically short, alphanumeric strings. In general, these identifiers must be unique.

The uniqueness is usually achieved in one of three ways:

1) The identifiers are assigned in a unique manner without using information associated with the individual. Example identifiers are:

```
ax54tv
cs00034
```

This method was often used by large timesharing systems. While it achieved the uniqueness property, there was no way of guessing the identifier without knowing it through other means.

2) The identifiers are assigned in a unique manner where the bulk of the identifier is algorithmically derived from the individual’s name. Example identifers are:

```
Craig.A.Finseth-1
Finseth1
caf-1
fins0001
```

3) The identifiers are in general not assigned in a unique manner: the identifier is algorithmically derived from the individual’s name

and duplicates are handled in an ad-hoc manner. Example identifiers are:

Craig.Finseth
caf

Now that we have widespread electronic mail, an important feature of an identifier system is the ability to predict the identifier based on other information associated with the individual. This other information is typically the person's name.

Methods two and three make such predictions possible, especially if you have one example mapping from a person's name to the identifier. Method two relies on using some or all of the name and algorithmically varying it to ensure uniqueness (for example, by appending an integer). Method three relies on using some or all of the name and selects an alternate identifier in the case of a duplication.

For both methods, it is important to minimize the need for making the adjustments required to ensure uniqueness (i.e., an integer that is not 1 or an alternate identifier). The probability that an adjustment will be required depends on the format of the identifer and the size of the organization.

2. Identifier Formats

There are a number of popular identifier formats. This section will list some of them and supply both typical and maximum values for the number of possible identifiers. A "typical" value is the number that you are likely to run into in real life. A "maximum" value is the largest number of possible (without getting extreme about it) values. All ranges are expressed as a number of bits.

2.1 Initials

There are three popular formats based on initials: those with one, two, or three letters. (The number of people with more than three initials is assumed to be small.) Values:

format	typical	maximum
I	4	5
II	8	10
III	12	15

You can also think of these as first, middle, and last initials:

I	4	5
F L	8	10
F M L	12	15

2.2 Names

Again, there are three popular formats based on using names: those with the first name, last name, and both first and last names. Values:

format	typical	maximum
First	8	14
Last	9	13
First Last	17	27

2.3 Combinations

I have seen these combinations in use ("F" is first initial, "M" is middle initial, and "L" is last initial):

format	typical	maximum
F Last	13	18
F M Last	17	23
First L	12	19
First M Last	21	32

2.4 Complete List

Here are all possible combinations of nothing, initial, and full name for first, middle, and last. The number of Middle names is assumed to be the same as the number of First names. Values:

format	typical	maximum
_ _ _	0	0
_ _ L	4	5
_ _ Last	9	13
_ M _	4	5
_ M L	5	10
_ M Last	13	18
_ Middle _	8	14
_ Middle L	12	19

_ Middle Last	17	27
F _ _	4	5
F _ L	5	10
F _ Last	13	18
F M _	5	10
F M L	12	15
F M Last	17	23
F Middle _	12	19
F Middle L	16	24
F Middle Last	21	32
First _ _	8	14
First _ L	12	19
First _ Last	17	27
First M _	12	19
First M L	16	24
First M Last	21	32
First Middle _	16	28
First Middle L	20	33
First Middle Last	26	40

3. Probabilities of Duplicates

As can be seen, the information content in these identifiers in no case exceeds 40 bits and the typical information content never exceeds 26 bits. The content of most of them is in the 8 to 20 bit range. Duplicates are thus not only possible but likely.

The method used to compute the probability of duplicates is the same as that of the well-known "birthday" problem. For a universe of N items, the probability of duplicates in X members is expressed by:

$$1 - \frac{N}{N} \times \frac{N-1}{N} \times \frac{N-2}{N} \times \ldots \times \frac{N-(X-1)}{N}$$

A program to compute this function for selected values of N is given in the appendix, as is its complete output.

The "1%" column is the number of items (people) before an organization of that (universe) size has a 1% chance of a duplicate. Similarly for 2%, 5%, 10%, and 20%.

bits	universe	1%	2%	5%	10%	20%
6	64	2	3	4	5	6
7	128	3	3	5	6	8
8	256	3	4	6	8	12
9	512	4	6	8	11	16
10	1,024	6	7	11	16	22
11	2,048	7	10	15	22	31
12	4,096	10	14	21	30	44
13	8,192	14	19	30	43	61
14	16,384	19	27	42	60	86
15	32,768	27	37	59	84	122
16	65,536	37	52	83	118	172
17	131,072	52	74	117	167	243
18	262,144	74	104	165	236	343
19	524,288	104	147	233	333	485
20	1,048,576	146	207	329	471	685
21	2,097,152	206	292	465	666	968
22	4,194,304	291	413	657	941	1369
23	8,388,608	412	583	929	1330	1936
24	16,777,216	582	824	1313	1881	2737
25	33,554,432	822	1165	1856	2660	3871
26	67,108,864	1162	1648	2625	3761	5474
27	134,217,728	1644	2330	3712	5319	7740
28	268,435,456	2324	3294	5249	7522	10946
29	536,870,912	3286	4659	7422	10637	15480
30	1,073,741,824	4647	6588	10496	15043	21891
31	2,147,483,648	6571	9316	14844	21273	30959

For example, assume an organization were to select the "First Last" form. This form has 17 bits (typical) and 27 bits (maximum) of information. The relevant line is:

17	131,072	52	74	117	167	243

For an organization with 100 people, the probability of a duplicate would be between 2% and 5% (probably around 4%). If the organization had 1,000 people, the probability of a duplicate would be much greater than 20%.

Appendix: Reuse of Identifiers and Privacy Issues

Let’s say that an organization were to select the format:

First.M.Last-#

as my own organization has. Is the -# required, or can one simply do:

Craig.A.Finseth

for the first one and

Craig.A.Finseth-2

(or -1) for the second? The answer is "no," although for non-obvious reasons.

Assume that the organization has made this selection and a third party wants to send e-mail to Craig.A.Finseth. Because of the Electronic Communications Privacy Act of 1987, an organization must treat electronic mail with care. In this case, there is no way for the third party user to reliably know that sending to Craig.A.Finseth is (may be) the wrong party. On the other hand, if the -# suffix is always present and attempts to send mail to the non-suffix form are rejected, the third party user will realize that they must have the suffix in order to have a unique identifier.

For similar reasons, identifiers in this form should not be re-used in the life of the mail system.

Appendix: Perl Program to Compute Probabilities

```
#!/usr/local/bin/perl

for $bits (6..31) {
        &Compute($bits);
        }
exit(0);

# ---------------------------------------------------------------

sub Compute {
        $bits = $_[0];
        $num = 1 << $bits;
        $cnt = $num;

        print "bits $bitsnumber $num:0;

        for ($prob = 1; $prob > 0.99; ) {
                $prob *= $cnt / $num;
                $cnt--;
                }

        print "", $num - $cnt, "$prob0;

        for (; $prob > 0.98; ) {
```

```
                $prob *= $cnt / $num;
                $cnt--;
                }
        print "", $num - $cnt, "$prob0;

        for (; $prob > 0.95; ) {
                $prob *= $cnt / $num;
                $cnt--;
                }
        print "", $num - $cnt, "$prob0;

        for (; $prob > 0.90; ) {
                $prob *= $cnt / $num;
                $cnt--;
                }
        print "", $num - $cnt, "$prob0;

        for (; $prob > 0.80; ) {
                $prob *= $cnt / $num;
                $cnt--;
                }
        print "", $num - $cnt, "$prob0;

        print "0;
        }
```

Appendix: Perl Program Output

```
   bits 6  number 64:
           2       0.984375
           3       0.95361328125
           4       0.90891265869140625
           5       0.85210561752319335938
           6       0.78553486615419387817

   bits 7  number 128:
           3       0.9766845703125
           3       0.9766845703125
           5       0.92398747801780700684
           6       0.88789421715773642063
           8       0.79999355674331695809

   bits 8  number 256:
           3       0.988311767578125
           4       0.97672998905181884766
           6       0.94268989971169503406
           8       0.89542306910786462204
           12      0.76969425214152431547
```

```
   bits 9  number 512:
           4       0.98832316696643829346
           6       0.97102570187075798458
           8       0.94652632751096643648
           11      0.89748056780293572476
           16      0.78916761796439427457

   bits 10 number 1024:
           6       0.98543241551841020964
           7       0.97965839745873206645
           11      0.94753115178840541244
           16      0.88888866335604777014
           22      0.79677613655632184564

   bits 11 number 2048:
           7       0.98978773152834598203
           10      0.97823367137821537476
           15      0.94990722378677450166
           22      0.89298119682681720288
           31      0.79597589885472519455

   bits 12 number 4096:
           10      0.98906539062491305447
           14      0.97800426773009718762
           21      0.94994111694430838355
           30      0.89901365764115603874
           44      0.79312138620093930452

   bits 13 number 8192:
           14      0.98894703242829806733
           19      0.97932692503837115439
           30      0.94822407309193512681
           43      0.89545741661906652631
           61      0.7993625840767998314

   bits 14 number 16384:
           19      0.98961337517641645434
           27      0.97879319536756481668
           42      0.94876352395820107155
           60      0.89748107890372830209
           86      0.79973683158771624591

   bits 15 number 32768:
           27      0.98934263776790121181
           37      0.97987304880641035165
           59      0.94909471808051404373
           84      0.89899774209805793923
           122     0.79809378598190949816
```

```
   bits 16 number 65536:
           37      0.98988724065590050216
           52      0.97996496661944154649
           83      0.94937874420413270737
           118     0.89996948010355670711
           172     0.79884228150816105618

   bits 17 number 131072:
           52      0.98993311138884398925
           74      0.97960010416289267088
           117     0.94952974978505377823
           167     0.89960828942716541956
           243     0.79894309171178368167

   bits 18 number 262144:
           74      0.98974844864797828503
           104     0.97977315557223210174
           165     0.94968621078621640041
           236     0.8995926348279144058
           343     0.7994422793765953994

   bits 19 number 524288:
           104     0.98983557888923057178
           147     0.97973841652874515962
           233     0.94974719445364064185
           333     0.89991342619657743729
           485     0.79936749144148444568

   bits 20 number 1048576:
           146     0.98995567500195758015
           207     0.97987072919607220989
           329     0.94983990872655321702
           471     0.89980857451706741656
           685     0.79974215234216872172

   bits 21 number 2097152:
           206     0.98998177463778547214
           292     0.97994400939715686771
           465     0.94985589918092261374
           666     0.89978055267663470396
           968     0.79994886751736571373

   bits 22 number 4194304:
           291     0.98999013137747737812
           413     0.97991951242142538714
           657     0.94991674892578203959
           941     0.89991652739633254399
           1369    0.79989205747440361716
```

```
   bits 23 number 8388608:
           412     0.98995762604049764022
           583     0.97997846530691334888
           929     0.94991024716640248826
           1330    0.89999961063320443877
           1936    0.79987028265451087794

   bits 24 number 16777216:
           582     0.98997307486745211857
           824     0.97999203469417239809
           1313    0.94995516684099989835
           1881    0.89997049960675035152
           2737    0.79996700222056416063

   bits 25 number 33554432:
           822     0.98999408609360783906
           1165    0.9799956928177964155
           1856    0.94998996696743165 38
           2660    0.8999664414095410736
           3871    0.79992328289672998132

   bits 26 number 67108864:
           1162    0.98999884535478044345
           1648    0.9799801637652703068
           2625    0.94997437525354821997
           3761    0.89999748465616635773
           5474    0.79993922903192515861

   bits 27 number 134217728:
           1644    0.9899880636014986024
           2330    0.97998730103356856969
           3712    0.94997727934463771504
           5319    0.89998552434244594167
           7740    0.79999591580103557309

   bits 28 number 268435456:
           2324    0.98999458855588851058
           3294    0.97999828329325222587
           5249    0.94998397932368705554
           7522    0.89998576049206902017
           10946   0.79999058777500076101

   bits 29 number 536870912:
           3286    0.98999717306002099626
           4659    0.97999160965267329004
           7422    0.94999720388831232487
           10637   0.89999506567702891591
           15480   0.7999860979665908145
```

```
   bits 30 number 1073741824:
           4647    0.98999674474047760775
           6588    0.97999531736215383937
           10496   0.94999806770951356061
           15043   0.89999250738244507275
           21891   0.79999995570982085358

   bits 31 number 2147483648:
           6571    0.98999869761078929109
           9316    0.97999801528523688976
           14844   0.94999403283519279206
           21273   0.89999983631135749285
           30959   0.79999272222201334159
```

References

Bruce Lansky (1984). The Best Baby Name Book. Deephaven, MN: Meadowbrook. ISBN 0-671-54463-2.

Lareina Rule (1988). Name Your Baby. Bantam. ISBN 0-553-27145-8.

Security Considerations

Security issues are not discussed in this memo.

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