Symbolic representations of telephone numbers

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INTRODUCTION

In writing of such things as telephone numbering plans, dialing plans, and the response of switching systems to dialed telephone numbers, it is convenient to have symbolic representations for:

a. What digit values are permitted in each position of the telephone number.

b. Identifying the three "fields" of the full telephone number.

Indeed conventions for both of those needs were developed. But sadly, those two issues have become entangled as those conventions arose.

This article tells that story.

1   SOME HISTORICAL PERSPECTIVE

1.1   Introduction

The earliest telephone "exchanges" used manually operated switchboards, at first not always the kind with a large field of jacks, as we have come to think of for manual telephone switchboards.

When the clientele of an exchange was only perhaps a couple dozen "subscribers" (as telephone customers came to be known), calls were placed by name. Perhaps Joe Porter had signaled the operator (often then spoken of as "Central") and asked to be connected to "Harry", or perhaps "Mrs. Williams", or perhaps "the feed store".

Of course as the number of subscribers increased, and with it the size of the cadre of operators, this became unworkable. Thus the practice arose of assigning numbers to the different "subscribers".

If we considered a town that at the time had perhaps 400 telephone subscribers, we might find these numbers: 1, 7, 23, 45, 101, 356. Now, if Joe Porter wanted to call the feed store, he would preferably ask the operator for "37".

As a town expanded geographically, and/or telephone service spread to the outlying areas rather than being solely available in the central area, it was not desirable to just make longer telephone lines from the

sole central switchboard. Rather, it became the practice to install separate switchboards in various parts of the town. The buildings where these were located became called (among other things "central offices".

One this happened, it became the practice to assign each central office a name,. which would be used when calling to identify the central office that served the called party (and within which the number was meaningful.) Often the original central office became "Main". One on the east side of town might be called "East", or perhaps "Lakeview", if that was the name associated with that part of town.

Now Joe Porter, wanting to call a friend who was served by the "Lakeview" central office, might ask the operator for "Lakeview 39".

It turns out that the maximum number of telephone numbers that could be served by one switchboard[1] might be 4800, or for an advanced design, perhaps 9600. In many case, for the larger systems, a four-digit number was standardized. That might in theory give us numbers such as 0005, 0037, 0528, and 4126. But the assignment of numbers with leading zeros was deprecated. That might have meant that the lowest number actually assigned was 1000.

1.2   Mechanization

It was an early dream of telephone system planners to be able to dispense with the labor cost of an ever-increasing cadre of operators by having what was often described as "automatic switchboards" (and later perhaps as "machine switching").

Although many schemes were implemented, it soon became the norm for the users of such a service to enter the number they wanted with a rotary dial. This dial generated "pulses" (periods of open-circuit on the line) which operated electromechanical switches at the central office.

For this to work out tidily, it was desirable for all telephone numbers in a given central office to have the same number of digits. But that might vary, even within one city, with the "size" of the central office.

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[1] It is common to speak of the capacity of a switchboard in terms of "lines", not "numbers", but that is in general inaccurate because of the use of 2- and 4-party lines, in which there would be 2 or 4 numbers "consumed" by a single line. And in the most common scheme in metropolitan areas, each jack on the switchboard corresponds to a telephone number, and the practical limit on switchboard size is really a limit on the number of jacks that can be placed within the reach of an operator..

The downtown" central office might use 4-digit numbers, while the one in some outlying district might have 3-digit numbers.

But there needed to be a way for the caller to indicate, with his dial, in which central office was the desired number served. The obvious way (if we imagine only perhaps 6 central offices in the entire city) was to have the first digit of the telephone number indicate the central office. This was in effect a 1-digit "central office code".

As systems grew, there was a wondrous panoply of different "plans" (and in some cases I use that word loosely) used for the evolution of telephone numbers. Quite commonly, although the first digit of the number consistently indicated the central office, as mentioned earlier the different central offices had numbers with a variable number of "station number" digits. Thus a number in the downtown central office (the "2"office) might be 24586, but a number in a certain outlying central office (the "4"office) might be 4283.

It was often (but not universally)[2] the practice to present these numbers in this form in the directory, on business cards, and such:

> 6-2368

2   AN ILLUSTRATIVE TELEPHONE NUMBER AND ITS "FIELDS"

An illustrative but imaginary US or Canadian telephone number of the form "standardized" in about 1950 (upon which I will concentrate here), as written in the all-numeric form that is what the dial actually sends and to which the central office actually responds, is:

> 311-555-2368

We can think of its three portions (separated in this presentation by hyphens) as "fields"[3], as follows:

- 311—I will generally call this the *area code*. Its formal name is *numbering plan area code*.

- 555— I will generally call this the *office code*. Its formal name is *central office code*.

- 2368—The *station number*.

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[2] For example, in Lorain, Ohio, a number in the "8" central office (with 4-digit station numbers) was presented in the directory as "89-191". The rationale was that customers could more easily remember a number if they thought of it in those terms.

[3] My term, not expected to be seen in the literature.

3   LETTERS AND NUMBERS

3.1   Introduction

Upon the instruction of "machine switching" ("dial") service by the Bell Telephone system in large and medium-sized cities, for the most part starting early in the 1920s, so as to facilitate the interaction between "dial" and "manual" central offices, the following clever scheme was adopted. It is generally attributed to W. G. Blauvelt of AT&T.

Dial central offices, as was true for the manual central offices that preceded them, were all given names (Fairview, Jefferson, Spring, etc.). When a manual office was converted to dial operation, it might keep its original name.

The dials for subscribers in "dial" central offices had the letters of the alphabet (except "Q" and "Z") placed in sets of three adjacent to the digits 2 through 9 (the now familiar arrangement). In effect each of those letters became an "alias" for a certain digit. These would be used by the caller to "dial" the first two or three letters of the central office name of the wanted number.

> For various reasons, the digits 0 and 1 were disallowed as the first digit of a telephone number; thus there would be no point in having letters that were equivalent to those digits.

The details in various situations were as follows

3.2   In the larger cities

In larger cities (New York, Chicago, etc., the number of central offices was so great that a three-digit central office code was needed. Thus the central office code was made the equivalent of the first three letters of the central office name. In the directory, those letters were in bold, alerting the caller that they were to be "dialed".

So if the caller found that the wanted number was shown in the directory as:

PENnsylvania 5000

he would "dial" PEN5000

but of course the digits that he really dialed were:

7365000

This format of the telephone number as presented eventually came to be identified as the "3L-4N" (3 letters, 4 numbers) format, sometimes just as "3-4" when the context was clear.

3.3   In the not quite so large cities

In modest sized cities (Cleveland, Pittsburgh), the number of central offices was modest enough that a two-digit central office code was used. Accordingly, the central office code was made the numerical equivalent of the first two letters of the central office name. As before, In the directory, those letters were in bold, alerting the caller that they were to be "dialed".

So if a Cleveland caller found that the wanted number was shown in the directory as:

CHerry 5283

he would "dial" CH5283.

but of course the digits that he really dialed were:

245283

This format of the telephone number as presented came to be identified as the "2L-4N" (2 letters, 4 numbers) format, sometimes just as "2-4" when the context was clear.

3.4   A change for the larger cities

Later, in the larger cities, it become increasingly difficult to find reasonable new central office names the first three of whose letters corresponded to central office codes that the telephone company would like to put into use as the number of central offices grew. To alleviate that, the presentation format of numbers in those cities changed. For example, for the new York example I gave earlier, that telephone number was then shown in the directory as:

PEnnsylvania 6-5000[4]

To reach that number, the caller would "dial":

PE65000

but of course the digits that he really dialed were:

7365000

just as before.

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[4] A great song.

This format of the telephone number as presented came to be identified as the "2L-5N" (2 letters, 5 numbers) format, sometimes just as "2-5" when the context was clear.

But for new central offices, the third digit would not be derived from the third letter of the central office name. So we might have, for a new central office, this number:

BRyant 2-7328

4   THE NEW NATIONWIDE NUMBERING PLAN

4.1   Introduction

During the late 1940s, planning began for a better overall way for "originating" long distance operators to complete the connection for a long distance call without involving any further operators. One aspect of this complex initiative was the "standardization" of the format of all telephone numbers, which began to take place in about 1949.

The longer-range objective of this new numbering plan was that it would be well suited for the subscribers to dial their own long distance calls without the use of any operators, soon brought about in a service called "Direct Distance Dialing" (DDD).

4.2   Standardization of the local telephone number

Under the new plan, all basic telephone numbers (this being called the *local number*, since this was all that would be needed to make a "local" call) would comprise 7 digits, a 3-digit central office code and a 4-digit station number. But the central office code was to be presented in the directory and such based on a central office name. [5] Thus a valid telephone number under the new plan, as it would be in the directory, might be:

ACademy 6-5569

which of course was actually, as sent by the dial and received by the central office equipment:

2265569

As we saw earlier, this format of the telephone number as presented came to be identified as the "2L-5N" format, sometimes just as "2-5".

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[5] In Lorain, Ohio, that resulted in the "8" central office becoming the "**AT**lantic 8" office, but at first the number I mentioned in my earlier note about Lorain was shown in the directory as **AT**lantic 89-191".

4.3   The Numbering plan areas

An impotent new ingredient in the new telephone numbering plan was that the entire US and Canada, were divided into a number of *numbering plan areas*. Within each numbering plan area, no telephone numbers were duplicated.

Each numbering plan area was assigned a unique 3-digit code, which was the first portion of what became the entire 10-digit "nationwide" telephone number. This code was called the *numbering plan area code*.

The abbreviation NPA was used for both:

- A *numbering plan area*
- A *numbering plan area code*

In general, the context suggested which was meant. And in any case, specific *numbering plan areas* were identified by their *numbering plan area codes* (as in, "He was served by a central office in the 505 NPA"). So the two meanings became essentially interchangeable. Still, we should be mindful that one of two things might be meant by "NPA" (maybe both).

4.4   The dialing plan

Simplistically, the initial plan was that the area code would only be dialed for long-distance calls where the called number was different from the area code of the caller.

So that the switching system could determine whether the first three digits dialed were an area code or a central office code, all area codes would have either "0" or "1" as their second digit. Those two digit value never appeared as the second digit of a central office code (because there were no letters on the dial associated with those two digit values, which came from th fact that the first digit of a number could not be "0" or "1").

4.5   All-number calling

It was eventually realized that the clever scheme of using central office names as part of telephone numbers had outlived it usefulness, and its continued use carried with it a number of problems.

As a result, starting in about 1960, there was a movement toward always presenting the telephone number as what it actually was, a set of 7 digits. Thus the iconic New York telephone number that was originally presented as:

PENnsylvania 5000

and later as:

PEnnsylvania 6-5000

would now be presented as:

736-5000

and was of course actually, as a train of digits to be dialed, just what it always had been:

7365000

This form of presentation of the telephone number was not called, for example, the "3N-4N" format, but rather was called the "all-number calling" (ANC) format.

5   DETAILED COMPOSITION OF THE TELEPHONE NUMBER

5.1   Introduction

Over the years, the "prescription" for the detailed (digit-by-digit) composition of a "standard" telephone number varied. Also over the years, different systems of symbolic description of that composition emerged.

Here I will refer to the notation under those systems as "format descriptors" [6]

5.2   An important reference

An important reference on these matters is a series of substantial volumes issued for some while by AT&T (and latter, by some successor organizations), and known over the years by various titles, for several years that being *Notes on Distance Dialing*.

In each edition, there is an extensive discussion of the numbering plan as it was defined at that time, and we find an interesting shift of the format descriptor system used to describe the permitted composition of the various parts of a telephone number.

Essentially, at different times, two wholly incompatible schemes were used.

I will summarize them here, under the editions of the document in which they appeared (among those in my library).

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[6] My term, not expected to be seen in the literature.

Notes on Distance Dialing–1956

The following symbols are used in the various digit positions in the number:

- L—A letter (that is, as written. From an actual technical standpoint, as generated by the dial and received by the central office, that means a digit with a value in the range 2-9).

- N—A number, that is a digit with any value, 0-9, in a position where it is "printed" as a digit.

- X—A digit with any value in the range 2-9, in a position where it is not "printed" as a letter.

- X'—A digit with a value of 0 or 1.

- X''—A digit of any value, 0-9, but subject to certain limitations (not described here).

Thus the format descriptor for an entire 10-digit telephone number was:

XX'X''-LLN-NNNN

I note, however, that in some other official Bell System document (sadly I can't just now recall what it was), a similar scheme was in effect, but used "A" (one might presume, for "alphabetic") to indicate a letter (in the same sense as "L" in the system above).

Notes on Distance Dialing–1968

Note that by this time, the use of letters in the presentation of telephone numbers had been discontinued, therefor this notation was not cast in terms of such an presentation.

The following symbols are used in the various digit positions in the number:

- N—A digit with any value in the range 2-9.

- X—A digit with any value (0-9).

- 0/1—A digit with the value 0 or 1[7]. This was sometimes written, when the typography allowed, as $\genfrac{}{}{0pt}{}{0}{1}$.

(Note that this is not in any way compatible with the convention used in the 1956 edition of this document.)

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[7] Yes, that is incredibly clumsy. They could have, for example, defined "Z" or "Q" as the symbol for "either 0 or 1".

Thus the format descriptor for an entire 10-digit telephone number (as then defined) is:

N 0/1 X-NNX-XXXX

The document also mentioned that, because of the fact that the available pool of valid area codes and office codes was nearing exhaustion, a plan was underway to dispose of the manifest distinction between area codes and office codes. When that plan would fully play out, the format descriptor for an entire 10-digit telephone number would be (and is today):

NXX-NXX-XXXX

There were of course various complicating ifs, ands, or buts that I will not discuss here.

6   SYMBOLIC FIELD DESIGNATORS

6.1   Introduction

In writing about numbering plans, dialing plans, and the response of switching systems to what is dialed into them, it would of course be handy to have some symbolic identifiers for the three fields of the telephone number as entities. Here I will identify these identifiers as *field designators*. [8]

For example, for that purpose, the following might have been adopted:

AC-OC-SN

where of course "AC" represents the *area code* field, "OC" represents the *office code* field, and "SN" represents the *station number* field.

6.2   The actual system

But no–it didn't happen that way. Rather this was adopted for the overall format of a telephone number in terms of "fields":

NPA-NNX-XXXX

Where:

• "NPA", the abbreviation for *numbering plan area*, represented the *area code* as an entity.

• NNX, which is the format descriptor for the *central office code*, here represented the *central office code* as an entity*.

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[8] This term is not often used in the literature of this field.

- XXXX which is the format descriptor for the *station number*, here represented the *station number* as an entity*.*

This is rather a polyglot notation, and is not at all attractive from a semantic standpoint. It is as of we designated the three major sections of an audio amplifier on the block diagram as the "preamplifier section", the "section with three tubes", and the "section with two tubes and a transformer".

Later, when the format descriptor for the central office code changed from NNX to NXX, even though that field had exactly the same significance as before, it (accidentally) got a new name. Now a telephone number's overall structure, in terms of its three constituent fields (their significance unchanged), would be written as:

NPA-NNX-XXXX

6.3   The irony here

The irony here is that while "NXX" in this situation is expected to unambiguously identify the *central office code*, at present the *area code* also has that same format descriptor, "NXX". But "NNX" does not refer to the *area code*.

There is of course no real problem that results from this. Still, when I say, speaking of the Cleveland telephone system of, say, 1948, that "a certain part of the switching equipment acted upon the 'NNX' part of the number", a modern reader might say, "Don't you mean the 'NXX' part of the number?".

No, I don't. What I really mean is the "COC portion of the number". But no readers familiar with telephone industry conventions would understand that.

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