DEDICATION

Tom Brokaw defined them as "America's Finest Generation". They came home from fighting World War II and built the finest telephone network in the world. It is in their memory that I dedicate this document.

About the Author

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Author's Introduction

It has been over 125 years since the invention of the telephone. The original telephone was a simple device that operated on Direct Current (DC). The telephone has evolved and has become a normal way of life and an expected appliance in our homes, offices and even on our persons. Millions of people have used the telephone without thought or worry about its functions or its reliability. It is the one appliance, in the home, that people never worried about. If it broke, or ceased to function, the phone company fixed or replaced it. Most people lived their lives thinking that there is only one "phone company". In the late 1960s, Ernestine, a character on Laugh In, indicated she was from "The Phone Company". In the movie, "The President's Analyst, the antagonist worked for TTC (The Telephone Company). In reality there were hundreds of telephone companies. All of these telephone companies completed calls to the rest of the world through long distance facilities designed and maintained by AT&T. In 1983, the U.S. Federal Courts broke up AT&T. Multiple long distance companies now were able to carry interconnecting telephone traffic. The consumer was turned loose into a competitive service that they did not understand. Two decades have passed since the AT&T breakup. In 1996, the U.S. Congress passed the Telecommunications Act of 1996. The major purpose of this act was to promote competition for local telephone services. Competitive local exchange carriers need telephone numbers and interconnection agreements in order to compete for communications consumers.

Technology innovations, such as mobile and packet switching, have also increased consumer choices. All of this has created chaos in the competition for resources of the

PSTN. Overall management of the PSTN has been lost. There is not even any common standard or definition of what constitutes the PSTN.

The communications industry, as a whole, has done a poor job of educating the consumer on the overall operation and importance of what we know as telephone service. Consumer groups are too busy criticizing phone companies than to educate consumers.

In an attempt to explain the operation of the PSTN, some historical data has been simplified and other sections are not discussed. Many more sections of the Plan exist other than numbering and switching. These sections include transmission, signaling, end user equipment and network management. These are contained in industry specifications.

For a complete history of the early years, it is suggested that one read "*Telephone, The First Hundred Years*" written by John Brooks and published by Harper & Row, Publishers in 1976.

Alexander Graham Bell is credited with the invention of the telephone in 1876. However, it was Theodore Vail that invented the "Phone Company". Mr. Vail became President of AT&T in 1885 and set its vision for decades to come. That vision was "one system, one policy, universal service".[1] That vision has brought the PSTN out of many disasters in its history.

At the time of the invention of the telephone, Thomas Edison had not yet patented the electric light bulb. Many decades passed before a cohesive telephone system was developed so that telephone users could call people over long distances. (For example, the first transcontinental telephone call did not occur until 1915) The early decades were full of local competition, inventions and litigations. Phone companies were created and equipment manufacturers sprang up. Sears & Roebuck and Montgomery Ward catalogs listed entire telephone line equipment for "Farmer's Lines". Interconnection standards did not exist until interconnection between companies and "Farmer's Lines" was attempted. The creation of AT&T as an overall carrier of inter-company telephone traffic created the need for standards to be developed. Some of these standards took decades of trial and error studies before they were codified. Human operators placed interconnections, and long distance connections. Methods for signaling each other were developed by mutual consent. Operators learned that the more switchboards that were interconnected, the harder it was to hear a conversation. As telephone technology developed into automatic connecting, the standards became more stringent. All of this took decades of work by scientists and engineers using slide rules and pencils. AT&T recognized the fact that a telephone system would only be perfected when **everyone** was connected to the system. This was referred to as "Universal Service". AT&T put together the Bell System. AT&T was a powerful political company that controlled the development, deployment and the interconnection standards for telephone systems until the U.S. Department of Justice broke up AT&T in 1983. Many international standards are still based upon the early AT&T standards.

This document refers to the North American Numbering Plan (NANP) and the Nationwide Toll Dialing Plan. For overall

[1] "Telephone, The First Hundred Years" by John Brooks and published by Harper & Row, Publishers in 1976.

simplification, I will just refer to this as the Public Switched Telephone Network (PSTN) unless the reference is just to numbers or switching. A Web Search of PSTN reveals several definitions of it. The most accurate is as follows:

The public switched telephone network (PSTN) is the concatenation of the world's public circuit-switched telephone networks. Originally a network of fixed-line analog telephone systems, the PSTN is now almost entirely digital, and now includes mobile as well as fixed telephones.[2]

The worldwide PSTN is largely governed by technical standards created by the ITU-T, and uses E.163/E.164 addresses (known more commonly as telephone numbers) for addressing.

The NANP PSTN is the North American segment of the worldwide PSTN and was created to be independent of the technology that is used in its operation.

I define the NANP PSTN as any group of networks that are used to complete public messages between a calling NANP number and a called NANP number through network elements defined in industry Rating and Routing data bases. This includes those elements that are part of the PSTN Signaling Network. (for example: The using of NANP numbers qualifies the element as being part of the PSTN)

In my opinion, once Internet Service Providers complete traffic by accessing elements of the PSTN, they become a part of the PSTN. If a company advertises that it is a new type of telephone company, advertises that it will complete calls using NANP numbers and interconnects with the PSTN for the access, then it becomes a telephone/communications company.

Prior to the MFJ, the prime objective, of phone companies, was to complete a call. The MFJ, bolstered by the Telecommunications Act of 1996, changed that purpose. The purpose is now to get paid for providing services.

The purpose of this document is to educate its readers on the history and philosophy of the PSTN. This will enable the reader to understand the PSTN's functionality and its benefits to the users of the system. Hopefully, this will enable regulators, providers and users to understand the need for considering the whole network as a functioning tool of our society and not just piece parts of various corporate business plans.

I sometimes feel that, in the not to distant future, we will wake up one morning with no dial tone and there will be no one who can fix it. I hope the reading of this document will prevent or at least delay that catastrophe.

Readers of this document may feel that it supports the views of the present RBOCs and AT&T. It is quite the opposite. It reveres the memory of past employees of the Bell System and the Independent Telephone Companies prior to January 1, 1984. In my opinion, the present RBOCs and AT&T relate to their predecessors in name only.

The opinions, conclusions and recommendations contained in this document are mine. They are in no way associated with my current employer, past employers or other industry affiliations.

[2] http://en.wikipedia.org/wiki/PSTN

EXECUTIVE SUMMARY

The North American Numbering Plan (NANP)[3] is the North American portion of the worldwide Public Switched Telephone Network. It was developed, coordinated and managed by AT&T from its inception in 1947 until the breakup of AT&T (MFJ) on January 1, 1984. It was then coordinated by Bell Communications Research Corporation (Bellcore), on behalf of the Regional Bell Operating Companies (RBOC), from 1984 until the enactment of the Telecommunications Act of 1996 (TA-96). Since that time, it has not been managed or even coordinated by anyone.

The result of this government opening of the PSTN is that it is no longer managed. It has gone from a seamless network with one goal to a hodgepodge of networks constructed by individual business plans. In the name of competition, it has created multiple segments of service providers each trying to interconnect with each other and yet manage to cut operating expenses. Each service provider segment has different perspectives on network operation and has different regulatory rules for their operation.

The FCC has extracted the numbering portion of the NANP and hired an independent contractor to administer the numbers without regard to the management of the network needed to switch the numbers.

Telephone numbering resources are the "source code" by which the plan's switching elements function. The plan established the format and values of telephone numbers used in the 19 nations that are associated with the plan. This plan established a fixed 10 digit format for NANP numbers. Just having a ten digit telephone number does not assure one of being able to make or receive telephone calls. Calls must be routed and properly billed by a comprehensive uniform method for rating and routing of the messages developed by the plan. Calls are routed and rated based upon the first six digits of a ten digit telephone number. The plan is totally independent of the technology that uses it.

The plan has evolved from manual connections to electro-mechanical switching to stored program controlled analog switching to stored program controlled digital switching and now to packet switching. It has included CMRS technologies from Mobil Telephone Service (MTS) to Cellular to Personal Communications Systems (PCS)

CMRS systems are only wireless from the customer instrument to the first tower site. After that, they must connect and switch through the wireline network.

The real problem is the fact that the PSTN still routes and rates messages exactly the way it was envisioned in the 1940s. The administration, handling and routing of telephone numbers is in at least five different data bases that do not communicate with each other.

The deployment and growth of the Internet has proponents promoting its use for voice traffic. This is called Voice over Internet Protocol (VoIP). Legislators and regulators have been asked whether this service should be regulated or not. Sides have been drawn. There is a big difference between talking

[3] The NANP is the basic numbering scheme for the telecommunications networks located in Anguilla, Antigua, Bahamas, Barbados, British Virgin Islands, Canada, Cayman Islands, Dominica, Dominican Republic, Grenada, Jamaica, Montserrat, St. Kitts & Nevis, St. Lucia, St. Vincent, Turks & Caicos Islands, Trinidad & Tobago, and the United States (including Puerto Rico, the U.S. Virgin Islands,

over the Internet and talking over an IP mediated network. The use of the Internet for voice traffic still needs PSTN high speed access and NANP telephone numbers to co-exist. End users must have electrical service in order to be able to call over the Internet. Once the Internet is used for public voice messages, it becomes part of the PSTN. It needs co-existence methods to enable the new technology to be deployed and be a virtual seamless network.

The following are some issues involved with deploying VoIP for use in telecommunications:

- Lack of a common cohesive network plan
- Lack of defined Quality of Service
- Lack of a common goal by service providers
- Lack of a common plan for co-existence with the circuit switched PSTN

The deployment of wireline telecommunications has had significant impact on people's ability to receive help and receive notifications for events associated with public safety and civil defense. **The PSTN was constructed and maintained for reliability and survivability**. Today, the Internet has limited capabilities for this. It is a commercial venture. Regulators, providers and users need to understand and consider the whole network as a functioning tool of our society and not just piece parts of various corporate business plans.

End users of telephone services want to reach the person they called. They do not care what technology is deployed between them and the party they are calling.

End users and government officials expect their communications systems to handle expected traffic volumes and function in times of emergencies.

On the cover sheet of this document, I asked who was managing the PSTN. The answer, to that question, is that nobody is managing the PSTN.

THE PAST – THE BEGINNING TO 1983

Section 1 – Telecommunications and Public Safety / Civil Defense

The deployment of telecommunications has had significant impact on people's ability to receive help and receive notifications for events associated with public safety and civil defense. One of the reasons farmers deployed telephone lines, even before they had electricity, was to get help in emergencies. Early community telephone operators knew who to contact and where that person was in order to respond to an emergency. Early telephone operators let regular calls wait in order that the emergency was responded to, quickly. Bell System operator training instructed operators on how emergencies were to be handled. These procedures were important enough to be placed "under the glass" immediately in front of an operator. Before the late 1960s, children were instructed to call the operator in the event of an emergency. An operator with an emergency stood up and was immediately joined by a group chief operator who plugged into the call to monitor and assist in the emergency. Operators spent hours locating family members to make notifications in the event of an emergency. Telephone operators stayed at their positions during all sorts of disasters in order to handle emergency requests. Deployment of government operated 9-1-1 Emergency centers has relieved telephone companies from the responsibilities of handling such calls. CMRS Carriers and many Competitive Local Exchange Carriers do not even provide operator services.

In the early years, the Bell System disseminated vital information by calling the Chief Operators. In turn, the Chief Operators notified community leaders. This was one of the uses of operator to operator calling. (As an example, when World War I ended, this information was sent out via chief operator notification. The Chief Operator then notified public officials and the local news media.).

Dial switching equipment contained equipment that could limit calling to only key people in the event of an emergency. This was done to protect the network from overload so that civil defense and emergency personnel could react to the event.

Before hand held radios, large metropolitan telephone companies provided and maintained "Police" call boxes that connected a police officer to the central police station for check in and dispatches. This equipment functioned on a ring down basis and messages were carried separate from the switched network in order to maintain the reliability and survivability of the system.

Rural telephone companies provided equipment and access to alert volunteer fire departments for deployment in the event of local emergencies. These systems rang the phones in a number of fire official's homes, when the fire reporting number was called. Buttons placed on phones in the homes of fire officials set off the local fire siren to alert other volunteers. Some local telephone companies actually had their operators handle emergency calls and dispatch police, fire and ambulance units.

Telephone company operators routinely connected police officer's calls to the police department from coin operated telephones.

Telephone equipment manufacturers built specific products for fire and police department's emergency communications needs. This equipment was installed and maintained by the local telephone company. Early systems deployed a telegraph system to alert emergency services that someone had "pulled" the box at a particular location. Most of these were replaced by ring down telephone boxes that connected the caller to a live emergency operator that could dispatch emergency equipment based upon the information given by the caller. These replacements occurred in the 1950s.

Today's stored program controlled switching systems have the ability to give priority to certain emergency traffic such as 9-1-1 calls. These switching systems can also shed normal traffic to prevent system overloads.

The U.S. Federal Government has procedures that utilize the PSTN in emergencies or failures in their communications systems. This capability is called the Government Emergency Telecommunications System (GETS). Telephone systems are equipped to give priority treatment to GETS calls.

It was AT&T that suggested that 9-1-1 be used as a nationwide access to emergency services. President Lyndon Johnson endorsed this proposal in 1968 and Bell Telephone companies immediately appointed 9-1-1 coordinators in each engineering organization. The present wireline and CMRS service providers have spent millions to give their customers access to emergency enhanced 9-1-1 public safety answering points (PSAP). They have also complied with the requirements of the Communications Assistance to Law Enforcement Act (CALEA).

The wireline telephone network serves as a backup and a fall back technology when other systems fail, batteries lose power or when emergency situations arise. CMRS and Internet technologies require external power to their systems. The wireline network still supports all previous technologies associated with it. Wireline systems can still handle traffic from ring down telephones. Wireline networks have network management controls to protect it from overloads and failures associated with emergencies.

Personal communications systems, such as CMRS, have extended a person's access to emergency services. These systems also connect to public safety agencies using the wireline network through interconnection.

Section 2 – Regulation and Perspective

SYSTEM REGULATION

After the expiration of the Bell patents, AT&T recognized that competition for telephone customers was not in their best interest. AT&T worked with various federal and state governments to establish itself as a monopolistic regulated utility.

The underlying principle, for this endeavor, was that the investment required to provide telephone service was a natural monopoly and it wasn't in the public's interest to have multiple providers tie up that much resources in attempting to provide service on a competitive basis.

In order to have a monopoly that guaranteed it income levels, the Bell System established guidelines that regulators could monitor to assure the end user of good service. As part of this service package, the telephone company controlled and owned the entire network including all terminal attachments to that network. This ownership of all equipment was defined as real property. Each part had an assessed valuation and property taxes were paid to local governments for this real property. As a result, the phone company was the largest or second largest tax payer in every community. The other largest taxpayer was usually the power company. This method of local taxation still exists for incumbent telephone companies.

Regulations allow state regulators to franchise telephone companies and review the quality of service provided by these companies. Franchises can be revoked by states if service quality diminishes. Equipment and operating expenses associated with this service guarantee were figured into the equation that established telephone charges.

In 1934, the U.S. Congress passed the Telecommunications Act of 1934. This Act created the Federal Communications Commission (FCC). The FCC created the Uniform System of Accounts so that utility finances could be reviewed in a standard format.

There were three basic jurisdictions of calls in the United States.

1.) Local area calls
2.) Intra-State calls
3.) Inter-State calls

Telephone equipment costs were categorized for each of these jurisdictions in order to determine charge rates, taxes and revenue divisions.

These definitions are important for the proper routing and billing of calls. The first two jurisdictions are regulated by State Public Utilities Commissions. The FCC regulates the third jurisdiction. All revenues and expenses were categorized by these three jurisdictions.

This guaranteed rate of return made AT&T stock a safe investment. Many people's life savings and pension plans were invested in AT&T stock. The guarantee also enabled telephone companies to concentrate on good service and service innovation. It enabled AT&T to grow through innovation and modernization.

WIRELINE HISTORICAL PERSPECTIVE

The following historical perspectives apply to the wireline telephone industry use of telephone numbers since CMRS and other users did not exist at the time the PSTN was developed and implemented.

Telephone numbers became necessary as soon as the first telephone operator could no longer remember what switchboard jack was assigned to the end user. The numbers initially were the manual switchboard panel and jack strip number assigned to the end user. Telephone numbers were only used for wireline telephone calls until Improved Mobile Telephone Service (IMTS) was initiated in the early 1950s. The numbering plan was originated as the Nationwide Operator Toll Dialing Plan. It was changed to the Nationwide Toll Dialing Plan. Later, this became the North American Numbering Plan (NANP). The development of the PSTN took many years and the Plan that was chosen placed a three digit area code in front of existing seven digit local numbers. The Plan was established before mobile telephone service. The Plan was finalized by AT&T on October 22, 1947 and later, shared with the independent telephone companies through the United States

Independent Telephone Association (USITA). **The Plan was developed to automatically route and bill telephone calls placed by long distance telephone operators.**

The Plan provided sufficient numbering resources to carry the telephone industry into the 21st century. Every telephone, in the numbering plan area, has had a unique 10 digit number associated with it since that time.

The NANP was developed in conjunction with a nationwide switching plan. The two plans are complimentary to each other. Switching is based upon the number resources and the number routing is based upon the switching plan.

For the most part, the numbering plan and the switching plan preserved state boundaries and assured state regulation of the service within the states. Investment and expenses can then be categorized by intrastate or interstate for rate purposes.

The Plan was only utilized by toll operators (Operator Toll Dialing) until 1951, when, on November 10, 1951, Englewood, NJ became the first community to access Direct Distance Dialing (DDD). The conversions to DDD were completed to the majority of areas within the US and Canada by the mid 1960s.

This wireline perspective is important to understand as the application of the PSTN to other than wireline industry segments gets convoluted due to technical needs, architectural differences and regulatory differences for these industry segments. The problems associated with other than wireline service provider applications of numbering will be covered later in this document.

Section 3 – Numbering

NANP FORMAT AND VALUES:

Almon Strowger patented the dial telephone in 1891. Prior to the deployment of dial switching, numbers were verbally passed between callers and operators and then between operators. Between 1891 and the development of the PSTN, local dialing could be anything from two to seven digits. This was dependent upon the size of the community, the size of the local calling area and the capabilities of the switching system(s) being used. As communities grew, and the amount of telephones grew, digits were added in order to complete calls.

By the 1930s, most large metropolitan areas were able to dial their own calls. Local service standards had been developed for quality of service. However, there was no uniform dialing plan for the entire U.S. Telephone operators accessed other operators in distant cities and then asked to be completed to a local number in that city.

AT&T developed a plan to allow calls to be dialed across the entire U.S. and Canada. This plan took almost a decade and a half to design and implement. Its implementation was delayed by World War II. AT&T settled on a ten digit plan. AT&T began implementation of the plan in 1947. The most notable part of the plan (to end users) was the development of a Nationwide Numbering Plan.

The numbering plan used in the United States, and the other 18 nations served by Country Code 1, is known as the North American Numbering Plan (NANP). It is based on a "destination code" principle where each main telephone (access line) in the NANP has a specific "address" or "destination code" assigned to it. The address is a ten digit number that consists of the following two basic parts:

1) **A 3-digit Numbering Plan Area (NPA) code, commonly called the area code**

2) **A 7-digit directory number that is further divided into two parts.**

   (a) **A 3-digit central office (CO) code. The term central office, or CO, code is used in this document because of its long standing use. In this application CO means the servicing end office that provides dial tone to the subscriber.**

   (b) **A 4-digit station number.**[4]

In the initial definition, the first two digits of the CO Code were defined by the first two letters of the exchange name (i.e. BEachwood 4-5789[5]). Exchange names were associated with geographic communities and letters were (still are) printed on telephone dials (the 1 or 0 dial positions or keys do not contain letters). The exchange names were carryovers from the manual switchboard days. This was known as 2-5 Numbering. This stood for 2 letters and 5 numbers. After the implementation of DDD, some exchange names produced duplicate two letter designations with other exchange names. AT&T published a standard exchange name document in 1955 to eliminate these duplications[6]. This caused some exchange names to be changed.

The four digit station number was chosen to accommodate some existing manual operator systems and certain switching equipment, called Terminal per Line (TPL). TPL equipment needed 1000 numbers for every 100 lines. This equipment then allowed up to ten telephones per line. The last digit of a phone number served by TPL equipment indicated the party position on a party line. That was important because the switching equipment needed that to determine the proper ringing scheme for that particular telephone. Customers served by TPL equipment usually had to change their number when they were lucky enough to get a private line. TPL switching equipment was still deployed in the PSTN well into the 1980s. Modern stored program controlled switches can still handle up to eight parties on a single line.

Some regulatory and industry documents erroneously define telephone numbers and line numbers as being synonymous. Line numbers are associated with the physical line equipment that connects a wireline customer to a wireline switch. Most stored program controlled switching systems can associate multiple numbers with a single line. They can also associate multiple lines to a single number.

Therefore, a NANP telephone number is a ten digit number that contains two 3-digit codes and a 4-digit station number. All other numbers, used by telephone systems, fall in the category of prefixes or access codes. The written and printed representation of a NANP number should be

[4] This section is taken from Notes on the BOC Intra-LATA Networks, version TR-NPL-000275, Issue 1, April 1986. This was the Bellcore document that succeeded the AT&T Notes on the Network and AT&T Notes on Distance Dialing. These AT&T documents are sometimes referred to as the "Blue Book".

[5] The Marvelettes, 1962, Tamia Records

[6] Bell System (AT&T) "Notes on Distance Dialing" 1955

NXX-NXX-XXXX. This will prevent confusion with any other communications system that utilizes a numbering scheme.

The values of NANP telephone numbers are the decimal digits 0 through 9. Initially, these numbers were generated by the opening and closing of a relay in dial pulse telephones. This pulsing was controlled by springs and cams that regulated the speed of the telephone's dial. The industry standard is ten pulses per second. In 1958, Bell Laboratories developed Dual Tone Multi-frequency (DTMF) tones to generate numbers and to speed up connections. This became known as "touch tone"[7] The characters # and * were added to push button phones. Four additional tone pairs were also defined with this signaling plan. Military uses of DTMF contained these four additional pairs. The DTMF frequencies and uses are in TABLE 8 in the Appendix. The additional characters, created with this plan, now serve as network control characters. The dial equivalent to the * is the digits 11. There is no dial equivalent to the # character.

EVOLUTION OF NANP FORMAT:

- <u>1947 Original NANP Format and Values</u> = **N (0 or 1)[8] X – NNX – XXXX where N = digits 2 through 9 and X = any digit of 0 through 9. The NNX portion of this plan consisted of 2-letters and 1-number. The 2-letters were the first 2-letters of the exchange name. (ex. BEachwood 4 was BE 4)**
- **<u>1975 NANP Format and Values</u> = N (0 or 1) X – NXX – XXXX**
- **<u>1994 NANP Format and Values</u> = NXX – NXX – XXXX**

The values Y and Z have been used by various authors when referring to a range of suggested values for a particular NANP proposal. Y and Z are only used in their algebraic representation and were not used in any official definition of a NANP Number.

The format of the NANP is sometimes written as **ABC-DEF-GHIJ** to facilitate discussion of any particular value within the format

PREFIXES AND ACCESS CODES:

The industry has always employed prefixes and access codes to access certain capabilities or call types. The most common prefixes are the digit 1 preceding a sent paid toll call and the digit 0 which precedes an operator handled toll call. These prefixes have evolved over time. (In fact, the first exchange to access Direct Distance Dialing (DDD) did not have to dial any access code. New York City did not have to dial any access code for long distance until it was assigned its second Area Code. Another early prefix, for long distance calls, was 112 (see TABLE 5 for 11X Codes). (The prefix 112 was chosen because it was the access code for the "Long Distance Operator".) The current list of commonly used wireline prefixes and access codes is contained in TABLE 3 in the Appendix. Prefixes are usually deleted or used in the originating switch before the

[7] Touch Tone is a registered Trade Mark of Lucent Technologies. Other names for this service include Digitone, Keycall, Tone Dial, Touch Button, etc.

[8] The use of the parenthesis in this instance indicates that the central digit of the Area Code could only be a 1 or a 0.

called digits are forwarded. This was not always the case in some rural areas.

OTHER CODES: Codes 000-199

By definition, the codes 000-199 were excluded from the original NANP format and all subsequent redefinitions. The values 0 and 1 in the "A" and "D" digit positions of a NANP number, creates the codes 000-199. These codes were excluded so that there would be no customer confusion or switching conflicts with prefixes such as 11X. The definitions and intent of the uses of the NANP requires some further clarification of codes 000-199.

The industry has always needed additional codes in the same basic format or length for use in the telephone industry to perform other functions. Some of these functions precede customer dialing of long distance calls. Since the values, of the codes, 000-199 are not part of the defined NANP format for either of the first two codes, these values can, and are, used for these other functions. Industry and regulatory discussions for using the codes 000-199, for CO Code relief, are defined as "D" Digit Release.

Because of the NANP exclusion, the codes 000-199 are used by the telephone industry for Test Codes, Inward Operator Codes, Special Billing Numbers, Revenue Accounting Office (RAO) Credit Card Numbers and special routing of calls. Most of these codes cannot be dialed by end users. Various switching systems have software checks that block calls to and from numbers with these values. These software checks were installed to minimize fraud. Operator Services switching systems have software tables to validate credit card calls that utilize these codes.

OTHER CODES: Special

In addition, special codes are used by the wireline industry to direct calls to specific call types, features or service providers (See TABLE 3 in the Appendix). These codes are usually listed as prefixes or access codes. Switching system digit analysis cannot process, conflicting, multiple uses of the same digits without a software trigger to cause the switch to query a database for additional routing information. These database queries are associated with Intelligent and Advanced Intelligent Networks. (IN & AIN). IN and AIN features can only be provided in stored program controlled switching systems.

OTHER CODES: Star * and Number Sign # [9]

To minimize the amount of confusion experienced by callers using these characters, there was an effort to standardize their use. It is also important that consistent terminology be known and used when referring to these characters. The (#) and the (*) should be called the number sign and the star, respectively. The terms number sign and star have been internationally agreed upon. Use of the terms asterisk for (*) and pound sign for (#) should *not* be used in documentation dealing with dialing procedures.

Currently, the characters (#) and (*) have the following general applications:

1.) The first use of the number sign (#) is as an end-of-dialing or concludes the present action and proceeds to the next action indicator. This end-of-dialing use exists today and avoids a timing period (for example, IDDD) using certain types of switching systems. The *conclude-and-*

[9] AT&T Technical Advisory #3, NPL 81-09-27, Issue 2, December 1, 1981

proceed use also occurs in some telephone credit card services where the customer wants to indicate that the present call is over and a new call is about to be placed (for example, sequence calling).

2.) The second use of the number sign (#) is as the first character when dialing a call that is a wideband or other data call requiring special treatment. In certain types of data calls, both an initial and concluding (#) may be required. Functionally, this is similar in many respects to the KP + (address) + ST multi-frequency signaling format used by operators.

There are also a number of non-standard uses of the # sign for PIN Number Calling features. The # sign is also used in a number of ancillary equipment attached to the PSTN. An example of this is voice mail.

3.) The first use of the star (*) is as a prefix when dialing a Vertical Service Code (VSC) (for example, call forwarding) of the form *XX(X). In this application, the (*) indicates to the switching system that the digits following specify a certain desired feature/service.

In order to allow rotary dial telephone access to vertical service codes, the digits 11 are translated to simulate the star key in stored program controlled switches.

Vertical Service Codes are classed as numbering resources. Their assignment is covered in INC documents and they are administered by NANPA.

4.) The second major use of the (*) button is to provide an error correcting function for customer-dialing of various strings on a sequential basis in response to prompting. This could include a customer interactive session with an operator services system when placing automated calling card billed calls. Instead of the customer hanging-up and redialing when detecting a keying error (before the card system detects the keyed error), the caller can simply enter the (*) button to back-up to some pre-established point and redial the segment in which an error was recognized by the caller.

N11 AND N00 Codes

During the development of the NANP, N11 Codes were reserved for telephone company services to replace the older 11X codes. Some local dial switching systems (i.e. Cross-Bar) used these N11 codes before the NANP was codified. (See TABLE 6 in the Appendix for N11 Codes) Excluding the N11 codes, the original NANP, format and values, defined 152 Area Codes and 540 CO Codes within each Area Code. The NANP went into service with 86 Area Codes.

N00 codes were reserved for future uses. The first of these uses was the 800 code for non-geographic automatic collect calls. This dial access, to collect calls, replaced the old manual operator Enterprise, Zenith and WX services. (See TABLE 7 in the Appendix for N00 Codes)

GROWTH OF AREA CODES AND CO CODES

One of two methods was used in the early days of the NANP to handle growth in certain areas. These were:

1) Split the existing NPA into two parts and assign a new NPA to one of the parts.

2) Realign the boundary between two existing NPAs so that a better balance is achieved in the number of telephones in each NPA.

In the 1970s, a third method was added to this list. The third method involved overlaying an existing Area Code(s) with the new code, thus having two area codes service the exact same geographical area. This method mandates 10 digit local dialing.

Growth, in CO Codes, was handled in one of three ways. These were:

1) Assignment of a new CO Code to an existing Central Office

2) Construction of a new Central Office with new codes

3) Realign the boundary between two existing Central Offices so that a better balance is achieved in the number of telephones in each CO Code.

These plans necessitated numbering changes for some subscribers in the affected areas. The industry has always had permissive dialing periods where both codes could be used to reach the same number until customers became familiar with the new dialing pattern.

With only rare exceptions, new Area Codes or Central Office Codes were put in service coincident with the delivery of a new telephone directory.

ADDITIONAL CO CODES WITHIN EACH NPA – PHASE I

By the end of the 1950s, certain Area Codes were running out of CO Codes. The Bell System expanded the CO Code resource by converting to All Number Calling (ANC). This replaced the 2-letter, 5-digit numbering scheme. This added 100 CO Codes in each existing NPA for a new total of 640. This change was administrative and needed no changes in switching systems. This change began in 1959 and was not fully completed until 1980. Even though we are "officially" on an ANC basis, there is nothing which prohibits one from still quoting their telephone number with the old exchange name. ANC was a public relations nightmare in many large cities, in the U.S., where people associated their social status by the exchange name[10].

ADDITIONAL CO CODES WITHIN EACH NPA – PHASE II

In the early 1970s, certain NPAs were again forecasted to exhaust their available CO Codes. Switch technology had progressed to the point to where some of the original restrictions in code format were no longer necessary. The Bell System expanded the number of available CO Codes in each NPA by changing the format of the CO Code from NNX to NXX. This plan added 160 CO Codes to each NPA for a new total of 800. This plan required that new specifications and development be done to existing switch and Operational Support System (OSS) requirements. The name of this plan was E-digit Unblocking.

ADDITIONAL AREA CODES

In the late 1980s, it was forecasted that the supply of 152 NPA Codes would exhaust by the mid 1990s. The industry developed a plan to redefine the NPA Code format from N (0 or 1) X to NXX. This plan was developed by Bellcore on behalf of the seven Regional Bell Operating Companies. This plan made the entire number of CO Codes available as Area Codes. This plan added 640 NPA Codes to the existing quantity of 152 and brought the total of NPAs available to 792. This plan took considerable planning, technical

[10] "Telephone, The First Hundred Years" by John Brooks and published by Harper & Row, Publishers in 1976.

specification work and switch development. It took over 5 years to implement.

This change necessitated changes is switch functions to allow timing delay sequences to be initiated in areas that had ambiguous Area Codes and CO Codes. This timing delay sequence can be eliminated by having mandatory ten digit dialing.

CALL ROUTING AND RATING:

Just having a ten digit telephone number does not assure one of being able to make or receive telephone calls. Calls must be routed and properly billed by a comprehensive uniform plan for rating and routing of messages.

The combination of Area Code plus CO Code defined the calling party's switching system and the called party's switching system. In addition, the combination of Area Code and CO Code defined the rate centers of the calling and called numbers. The switching system location defined the "wire center" for call routing purposes. The rate center defined the geographic destination for customer billing purposes. Rate Center definitions are filed in tariffs with the FCC and various state regulatory agencies. Wire Center and Rate Center destinations can be the same, but their definitions and uses reside in different industry data bases. Wire Center information is "programmed" into switch routing tables and Rate Center information is "programmed" into computing systems used to generate billing information based upon dialed digits.

In other words, calls were routed from the switch that contained the calling party's line and number to the switch that contained the called party's line and number.

METHODOLOGY FOR ROUTING AND RATING

Each Wire Center and each Rate Center were (and still are) given vertical and horizontal map coordinates (V&H). Call routing and call rating are done by analysis of NPA NXX to NPA NXX. By subtraction of the V&H coordinates, and the use of the Pythagorean Theorem, the airline miles between any two rate centers can be determined[11]. These miles are converted to rate steps. Tariff charges, per rate step, are filed with respective state and federal regulatory agencies. These charges form the distance portion of chargeable calls. Local calling areas were established by figuring at what distance the processing of the charges became more expensive than the collection of the charges.

Airline miles between wire centers and points of connection are used to determine the distance portion of Carrier Access Billing (CABS) and for Meet Point billing between phone companies.

Routing a call was simple in the original plan. Switching systems were assigned in a particular NPA and this was called the Home Numbering Plan Area (HNPA). A call to any other area code was to a Foreign Numbering Plan Area (FNPA). Any ten digit call to an FNPA was routed to AT&T. AT&T routed the call according to the switching plan. The philosophy of routing was to complete the call as quickly as possible with a low probability of call failure.

Since the telephone industry only rates and routes calls based upon the first six digits of a telephone number, there are millions of numbers that cannot be used because of the geographic reliance of the first six digits.

[11] Telcordia Notes on V&H Coordinates, SR-Notes-Series-20

Regulators and other public officials recognize that there are more numbers than people and think this is a problem that the telephone industry is perpetuating upon the general public in order to raise rates and confuse customers.

Wireline telephone numbers were created with geographic significance. CMRS number assignment followed that geographic significance based upon the location of the serving CMRS switch. However, CMRS roaming removes that geographic significance. In addition, large metropolitan areas have added so many new codes, due to demand, that the geographic significance has diminished.

The PSTN was designed, coordinated, managed and maintained by AT&T Network Planning until the break up of the Bell System in 1984. The PSTN was then administered by Bell Communications Research Corporation (Bellcore) on behalf of the seven Regional Bell Operating Companies (RBOCs) until the Telecommunications Act of 1996 (TA-96). The U.S. FCC, in cooperation with the telephone industry and state regulators, contracted the administration of the numbering resources to NeuStar (See TABLE 1 in the Appendix). The Canadian CRTC awarded the contract to SAIC Canada to administer telephone numbers in Canada. The telephone industry is still developing refinements in the administration of the NANP.

Even though the NANP preceded it, the NANP follows international standards and is compliant with the International Telecommunications Union (ITU) Recommendation E.164 "Public Telecommunications Numbering Plan" (See TABLE 2 in the Appendix). This is essential for participation in International Direct Distance Dialing (IDDD).

(Even though a NANP number format is illustrated as NXX-NXX-XXXX, its ITU E.164 number is illustrated as 1-NXX-NXX-XXXX, since the Country Code for North America is 1.

EXPANDED INTERNATIONAL DIALING

In the late 1980s, the International Telecommunications Union (ITU) realized that the world was exhausting its numbering ability to handle new entrants into the world of International Direct Distance Dialing. This was exacerbated by the break up of the Soviet Union and the splits in Eastern Europe. The ITU issued its Recommendation E.164 "Public Telecommunications Numbering Plan". This recommendation expanded the amount of digits needed for IDDD from 12 digits to 15 digits. This expansion took considerable standards work on switching, billing and other operational support systems OSSs. This expansion took place on January 1, 1997.

INDUSTRY CONTROL OF NUMBERS

Telephone numbering resources are the "source code" by which the Public Switched Network (PSTN) elements function. Each technology that uses NANP numbering resources is constructed using the format and values of the Plan.

Electro-mechanical telephone central offices had to be provisioned with physical switching equipment to complete calls to telephone numbers. Stored program controlled systems only have computer memory addresses associated with numbers. Stored program controlled switching systems use the numbers to obtain the address location of the physical line equipment (line number) that connects the customer to the switch. Telephone numbers are signaled between switching systems, to complete telephone calls. The calling party's telephone number and the called party's telephone number are parts of the data recorded on message accounting media for proper billing.

Control of the assignment of Area Codes and Central Office Codes were as important to telephone companies as the use of the numbers themselves. AT&T controlled the assignment of Area Codes and the Bell Operating Companies controlled the assignment of CO Codes. Heavy traffic volume areas were assigned area codes based upon minimizing the spin of a rotary dial for areas that had large long distance call volumes. In addition, switching equipment work times, in these areas, were minimized due to a smaller count of dial pulses generated by the caller (or operator) and received by the equipment. Area Codes with a 0 as the central digit were assigned to states or provinces that were expected to have only 1 Area Code. Area Codes with a 1 as the central digit were assigned to states or provinces that were expected to have multiple Area Codes.

In cities that had step-by-step switching equipment, it was advantageous to grow with new CO Codes that would have the same first two digits as the existing NNXs. This kept the same geographic name and meaning as existing codes and lessened the need for intermediate selector additions to the equipment. Telephone numbers could not be assigned in sequence in these offices, because traffic load balance needed to be evenly spread over the switching equipment that was associated with telephone numbers.

In addition, cities with large metropolitan calling areas needed new CO codes that could be handled easily in step-by-step tandems. Call signaling, between central offices could then be done with a minimal amount of digits to minimize switching equipment requirements and to speed up connections. In other words, if a switch only needed 4 digits to complete a call, the tandem office would only forward 4 digits to that switch.

CO Codes with high numbers (i.e. 998) or numbers that did not fit into large city dialing plans were assigned to rural areas that did not have a large calling area.

All of this caused a high number of CO codes to be reserved for future use in specific areas.

Historically, the telephone industry has routed telephone calls based upon three or six digits in order to minimize delays in calls caused by digit analysis. Each of the codes in the original NANP had different formats. Electro-mechanical switch decisions relied on the two codes being different in order to minimize timing delays in call processing. Subsequent redefinitions of NANP values have resulted in the format of these two codes being exactly the same. The necessary information, needed for call routing instructions, is now contained in the Telcordia™ LERG™ Routing Guide. The rating information is based upon data contained in the Telcordia™ TPM™ Data Source.

CMRS SERVICE PROVIDERS (CELLULAR AND PCS) USES OF NUMBERS

Even though the Wireless Industry utilizes NANP numbering resources, it does not always use standard prefixes or access codes. The wireless industry also has other numbering requirements, separate from the number associated with the CMRS subscriber. Most of these requirements are necessitated by CMRS roaming and access to emergency services via 9-1-1 (See TABLE 9 in the Appendix).

Mobile Telephone Service (MTS) was developed by the Bell System and introduced in 1946. Mobile telephones were connected to the network by using adjunct radio equipment interfaced into existing electro-mechanical switching systems on a line and/or trunk basis. This adjunct equipment connected switches to radio antennas for connection to the mobile phones. Roaming was handled by connection to a live telephone operator in a toll center. Telephone numbers associated with mobile phones were part of the serving telephone switching office. MTS evolved into Improved Mobile Telephone Service (IMTS) in the early 1950s. IMTS was expensive and unreliable.

Cellular technology was invented before the breakup of AT&T (MFJ). However, the deployment of the technology did not occur until after the MFJ. Early cellular technology was expensive, bulky and had sporadic service areas. PCS technology occurred later, but PCS number usage and interconnection follows the same pattern as cellular. Initial deployment of this CMRS form of telecommunications was slow to deploy due to the expense and the complexity of the instruments. CMRS switching systems were no longer adjuncts and are the CMRS equivalent to the wireline end office. **CMRS systems are only wireless from the customer instrument to the first tower site. After that, they must connect and switch through the wireline network,** unless the call is between two CMRS customers served by the same switching system.

Technological differences have allowed CMRS switching systems to serve much larger geographic areas than wireline switches. Even though CMRS switches perform the same function as wireline switches, they interconnect in different manners[12]. CMRS interconnection to the PSTN follows much the same methods that the Bell System developed for IMTS in the 1950s. CMRS service providers also have different regulatory rules. They can cross LATA and state boundaries.

Evolution in inter-company business arrangements, and instrument capabilities have expanded the role of CMRS roaming into true portability. However, roaming necessitates the need for an additional number to be assigned to the roamer for message rating purposes. Even though the end user pays a flat rate and has nationwide free roaming, the inter-company billing arrangements still are based upon point of origin to point of termination. Local taxes applied to these calls are also dependent on the jurisdiction of the originating location and the terminating location. Emergency access code (9-1-1) requirements also necessitate other temporary numbers be assigned to a CMRS roamers. All of this complicates telephone number demand.

The current NANP format enables the CMRS Industry segment to utilize numbering resources listed in TABLE 9 of the Appendix. Unless otherwise noted, numbers so utilized cannot be used for other purposes such as assignment to subscribers.

PACKET NETWORKS (VToA AND VoIP) USE OF NUMBERS

End users of telephone services want to reach the person they called. They do not care what technology is deployed between them and the party they are calling. The PSTN was created to be independent of technology. End users also want reliable inexpensive service. Packet technology has

[12] Wireless Basics 2nd Edition by Harry E. Young

existed for decades and has been used to transmit data. It is also used by the telephone industry for the signaling portion of the voice network. Early trials of transmitting voice over this type of network proved to be unreliable and of poor quality. Recent technology improvements have solved most of those early problems. Packet switching is now beginning to be deployed for use in voice networks. Packet technology uses of numbering resources will depend largely on how this technology interfaces and interoperates with the existing Public Switched Telephone Network (PSTN). Co-existence is essential for proper evolution and transformation from circuit switched to packet switched networks. If this technology interfaces are an adjunct to the existing PSTN, then the use of telephone numbers could be different than the existing architecture. This technology may not need traditional telephone numbers at all. If this technology is defined and interfaces in the same way as circuit switched voice, then the impact on numbering will be minimal. Only time and consensus standards can determine the long range impact on the NANP.

Section 4 - The Nationwide Toll Dialing Plan

POWERING THE SYSTEM

The original telephones each had their own batteries that supplied power. A crank on the side of the phone generated additional electricity that rang the phones, on the line, when the crank was turned and the phones were on their hook. Telephone companies sold Dry Cell Batteries for the phones. As each phone's batteries discharged, the transmission quality decreased. Sending someone out to replace the batteries became a chore. Later systems provided the battery power back at the Central Office. This newer type of phone system was called "Common Battery". The batteries could be maintained at the Central Office. The first Common Battery system was put into service in Worcester, Massachusetts, in 1896.

Telephones are still DC powered. This is important, because the loop resistance is still a deciding factor in wireline telephone signaling. This loop design includes the resistance of the telephone set. Wire Centers are constructed in order to adhere to Ohm's Law. The Bell System constantly improved the capabilities of telephone sets to lower the resistance. The power standard that was developed in the early years was 48 Volts, DC.

Telephone switching systems are still powered by batteries. Batteries can also serve as back up, when electricity is interrupted. They also serve as a filter to eliminate random electrically generated noises from AC power. Commercial electric power is used to charge the batteries. Standards have been developed to provide sufficient battery life to power the phone system for a number of hours when commercial power is interrupted. Federal and State regulations have been established to mandate the amount of time needed to sustain telephone service in times of commercial power failure. In modern times, most telephone Central Offices have been provided with a back up generator to provide the electricity to charge the batteries when commercial power fails. Telephone system practices and standards have been developed to maintain the batteries and generators so that they are always in top condition. Battery life cycles have been calculated and the batteries are replaced on regular intervals.

The button that pushes down when you hang up the phone is still called the switch hook. It is named after the switch on the side of the phone that looked like a hook. The receiver (the part that you put up to your ear) had an "eye" attached to its top and the "eye" part was hung on the hook. The hook pulled down from the weight of the receiver and opened a switch that disconnected the phone from the line. When the receiver was removed from the hook, spring pressure moved the hook upward closing the switch and the phone was then connected to the line. This connection caused current to flow and lit a lamp at the local switchboard. In old movies, you sometimes see an actor quickly moving the switch hook up and down. This caused the operator lamp to flash. Customers had the mistaken impression that this would cause the operator to answer the call faster. The flow of current in dial systems caused the customer to be connected to the dial tone source.

The most common form of signaling a phone to ring is called "superimposed". This method puts Alternating Current (AC) out on the telephone wire loop. The phone is on the hook, so the loop is open. However, a coil is across the line. The AC energizes the coil, which then causes the ringer to operate.

The other major phone signaling situation occurs when someone picks up the phone handset. This closes the switch and causes current to flow in the loop. In the early days, this caused a lamp to light in the switchboard. In dial systems, it caused the electro-mechanical switch to find the line the current was flowing from and connect it to dial tone. In modern stored program controlled systems, the current flow causes a computer processor to recognize a change in state and connect the phone to dial tone and devices to capture digits dialed or pulsed.

CONNECTION TO THE SYSTEM

Community switchboards were placed in central locations, usually in the main office of the phone company. In smaller communities, this could be the home of the telephone operator. These became known as the Central Office. Each and every phone line had a physical pair of wires connecting it to the central office. Each and every phone line had a resistance limit that determined how far away from the Central Office it could be located. For all intensive purposes, this loop resistance limit still exists. (Electronics and computerization have created "simulated" cable pair connections to the Central Office that can increase the distance the end user can be from the switching equipment.) Operators physically answered each call and manually connected the parties with a patch cord. The operator positions had cord pairs. The front cord answered the call and the back cord connected the call forward. Small town operators knew everyone and knew where everyone was. They could connect you to your party even though the person was at someone else's house. This was an early form of "Call Forwarding". If the line you were calling was in use, the operator informed you that the line was "busy".

The switchboards in various cities and towns were interconnected, electrically, by facilities called trunk lines. This term is still used to define interconnection facilities.

By the 1930s, most metropolitan areas of North America had replaced local telephone operators with automated switching systems.

These automated systems were interconnected by trunk lines or trunks as they ultimately became known. Accessing long distance could be done by dialing 112 or dialing 0 and asking for the long distance operator. The operators associated with dialing 0 usually worked for the local telephone company and the long distance operators worked for AT&T.

AUTOMATING THE LONG DISTANCE OPERATOR

Prior to automation, telephone operators had precise written directions for placing long distance calls. They also did not have trunks to every place needed. These directions were created to minimize the amount of switchboards that needed interconnection in a given long distance call. This was done to minimize the transmission loss to enable the customers to hear each other.

An operator would accept the call from an end user and call back the end user when the long distance call was set up. An operator would call another operator up the chain to place the call. That operator would then call the next operator until the call was set up from one locality to the locality of the receiving end user. The original operator would call back the call originator and announce that the called party was on the line. If any operator in the route of the call set up encountered an all circuits busy condition, the call would be terminated until an idle circuit became available. The process then started all over. During busy times, a long distance call might take hours to complete. However, the originating customer only paid for the call if and when it completed. Billing was set up based on the distance of the call and the time involved in the conversation. Prices varied dependent upon the time of day and the day of the week. This system charged premium rates for high volume weekday business hours and lower rates for weekends, evenings and nights. Long distance charges were inflated to offset the high cost of building out the telephone system to rural areas. This build out followed the Universal Service goal mentioned earlier.

The Bell System realized that considerable operator work times could be saved if the call routing decisions were made automatically

In the 1930s, Bell Telephone Laboratories was busy trying to develop new and faster switching systems. They settled on the use of a crossbar switch technology patented by L. M. Ericsson Company in Sweden. The original production models of these crossbar switches were deployed in the larger metropolitan areas of the U.S. and Canada before operator automation. Additional work continued on these types of switches to automate the routing of long distance calls placed by operators. World War II put a temporary delay on the deployment of this technology.

The Bell System published the Operator Toll Dialing Plan, on October 22, 1947, utilizing the unique ten digits created by the NANP and the newer switch technologies. The Operator Toll Dialing Plan was shared with the independent operating telephone companies through the United States Independent Telephone Association.

The Operator Toll Dialing Plan, was created utilizing a hierarchical switching arrangement (see Appendix, Figure 1) that assured that no telephone call would switch more than ten times[13]. This switching plan was designed to minimize the probability of encountering an "All Trunks Busy"

[13] Bell System (AT&T) "Notes on Distance Dialing", 1975

condition and to maintain a consistent volume level for speech quality. The speed and architecture of the switching plan enabled long distance calls to be made faster, which lessened operator work times. This reduced the need for operators. This Plan was totally dependent upon the geographic significance and uniqueness of the numbering system.

This plan worked because each end user had the unique ten digit telephone number created by the plan and the switching plan was uniform and seamless. The first six digits of the telephone number identified the wire center and rate center of the called number. Routing was accomplished in the switches associated with the plan. Trunk interconnections and digit translation assured the fixed availability of the system.

CUSTOMER DIALING OF LONG DISTANCE

The next step was to connect the local switches to the switches utilized by the Operator Toll Dialing Plan. This connection started in the early 1950s and Englewood, New Jersey became the first community to access DDD on November 10, 1951. DDD was completed to most areas of North America by the mid-1960s.

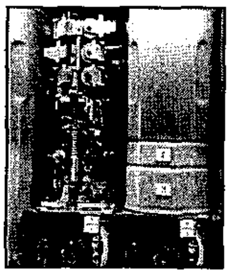
In 1955, the AT&T Notes on Distance Dialing officially changed the name of the Plan to the North American Numbering Plan (NANP).

<u>Section 5 – Evolution of Technology</u>

As soon as there were more than two telephones that needed to be interconnected, a method was needed to accomplish this feat. This need produced the switchboard. This device took all of the wires from the various telephones and connected them via patch cords. The first commercial switchboard was placed into service on January 28, 1878 in New Haven, Connecticut. Initial telephone systems were magneto sets that were self powered and generated ringing current via a hand cranked magneto. The central switchboard also signaled in the same manner. In other words, you cranked your telephone to signal the operator and picked up the receiver and waited for her to answer. When the operator forwarded the call, the operator cranked a magneto to ring the called party. As switchboard size grew, additional positions were added and additional jack strips were added up to the height that could be reached by an operator. Early switchboards evolved into common battery systems where the power was furnished at the Central Office and ringing could be applied by throwing a key to apply ring current. Common Battery systems only became viable after the deployment of commercial electrical power.

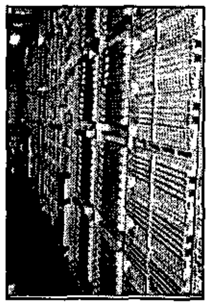
DIAL SYSTEMS

The demand for telephone service and the increased traffic generated by each telephone user soon created a need to automate the placement of calls. This requirement was also needed to reduce the need to hire more telephone operators.



Telephone equipment engineers looked to the Almon Strowger invention and began to build systems based upon the concept. This equipment was called Step-by-Step. It was so named because each digit dialed would "step" a switch the amount of levels indicated by the dialed digit. The limitations of this technology were the traffic that could be handled by the switching limitations imposed by a base ten system. In other words, any given element of the system could only access ten elements in the next switching stage. These elements were also shared with other accesses. This created a complicated method for traffic engineering and traffic load balance.

In the early 1930s, Bell engineers began looking to another system developed by L. M. Ericsson in Sweden. This system utilized a different switching arrangement and was called Crossbar. This



switch type could be interconnected to carry much larger amounts of traffic. The most common local office Crossbar switches, in the Bell System, were the #1 Crossbar and the #5 Crossbar. The #4 Crossbar was used exclusively for toll switching. The #1 Crossbar and the #5 Crossbar could also be adapted to toll switching applications.

Various equipment suppliers developed equipment for the independent telephone companies. Most of these were adaptations of Step-by-Step or Crossbar technology.

The Nationwide Toll Dialing Plan was created to be independent of the type of switching equipment using the PSTN. The PSTN allows all types of equipment to use it. How a particular piece of equipment is used determines its definition in the switching plan hierarchy. As switching equipment evolved, it fit into the application for which it was intended in the PSTN.

INTEROFFICE SIGNALING

The design and implementation of the PSTN allowed interswitch signaling to be done on the same path that would be used for conversation, once the call is set up. This signaling could be in the form of "dial pulse" or Multi-Frequency". In the 1970s, AT&T developed a program to increase the percentage of billable traffic that was completed on the network. Part of this effort was the development of Common Channel Signaling (CCS). CCS performed interoffice signaling on a separate path than the path used for conversation. This system was only deployed in the long distance part of the PSTN. After deployment, only valid billable messages were carried on the voice path.

International standards bodies were also in the process of developing CCS and developed a method called CCS7. AT&T adopted the standards used for CCS7 for the PSTN. These standards were modified for North America due to different information requirements. International carriers deploy "Gateway" offices that convert international CCS7 messages to North American CCS7 messages and vice-versa.

In the PSTN, this signaling method is just referred to as SS7. SS7 is important as it is necessary for the telephone network to be able to perform tasks later mandated by the MFJ and TA-96.

SUMMARY – 1947 - 1983

The Telephone Systems in the United States and Canada handle millions of toll calls a day. These were routed over a network of long haul intertoll trunks which interconnected approximately 2,600 toll switching offices and, with a few exceptions, all of the telephones in these two countries.

Large volumes of traffic between toll offices were generally routed economically over direct intertoll trunks. When the volume of traffic was small, however, the use of direct trunks was usually not economical. In these cases the traffic was then handled by connecting together, by means of switching equipment at intermediate toll offices, two or more intertoll trunks to "build up" the required circuit. "Built-up" connections involved several intertoll switching points if the originating and terminating points were a great distance apart and the traffic volume was small. Although this multi-switched traffic constituted only a small portion of the total, it was important that telephone plant be designed to care for it as well as for the greater volume that was handled via the less complex direct and single switch routes.

The conditions under which toll traffic was automatically switched on a nationwide scale were quite similar to those found in large cities with large volumes of traffic between many separate switching centers. Therefore, experience gained in these places was applied to the nationwide dialing job.

The needs of multi-office exchange areas were met by switching and trunking plans that employed a new principle, "automatic alternate routing", to provide rapid and accurate connections with few occasions for repeated attempts (see Appendix, Figure 1). With this principle, a call which encounters an all trunks busy signal on the first route tested was automatically and rapidly "route advanced" and offered to one or more alternate routes, in sequence.[14]

Up until 1983, AT&T controlled the end to end connections for all telephone calls in the U.S. This was done through their Bell Operating Companies and various independent telephone companies that followed the same interconnections standards and philosophies as the Bell System. In essence, the PSTN was a seamless network.

[14] http://www.telephonetribute.com/

THE PAST – 1983 – 1996

Section 1 - Regulatory

MODIFICATION OF FINAL JUDGMENT (MFJ)

In November 1974, the U.S. Department of Justice filed an antitrust lawsuit against AT&T. In January 1982, the parties reached a settlement. This settlement had AT&T divest itself of their local telephone company subsidiaries. AT&T retained control of their long distance subsidiary, their manufacturing arm (Western Electric) and their Operator Services business. This is referred to as the Modification of Final Judgment (MFJ).

Prior to the MFJ, the PSTN was designed and defined by engineers based upon service requirements based upon actual traffic measurements. After the MFJ, the PSTN was driven by economists.

The Department of Justice's MFJ broke the seamless national network into 164 separate pieces called Local Access and Transport Areas (LATAs) to handle local phone traffic. Through this move the DOJ created two distinct types of service providers: local exchange carriers (LECs) and interexchange carriers (IXCs).[15]

All calling between LATAs had to be handed off to the new competitive Interexchange Carriers (IXCs).

Even though the MFJ created LATAs, the actual area that defined each LATA was defined by the new RBOCs. The engineers associated with designing and administering the trunking in each area, were given the task of LATA definition. Hence, each LATA coincided with the area of

[15] http://www.bellsystemmemorial.com/

responsibility for these engineering groups. Later, independent telephone companies established their own LATAs and LATA connection points.

The MFJ created four basic jurisdictions of calls in the United States.

1. Local area calls
2. IntraLATA - Intra-State calls
3. InterLATA – Intra-State calls
4. InterLATA - Inter-State calls

The first three categories are regulated by state public utilities commissions and the last category is regulated by the FCC

Telephone traffic to each of these jurisdictions must be routed over separate trunk groups in order to properly categorize the investments and costs for each category. This is done for rate development, intercompany billing, taxation and revenue division.

The basic premise of the MFJ was to allow competition in the Long Distance toll business. LECs were only allowed to handle local and IntraLATA toll traffic. All InterLATA toll traffic had to hand off to an IXC. The LEC restrictions were only mandated to the Bell operating companies and GTE but applied to other phone companies that had valid requests from IXCs.

REGIONAL BELL OPERATING COMPANIES (RBOCS)

The seven RBOCs created by the MFJ were:

- **Ameritech**
  Illinois Bell Telephone Company
  Indiana Bell Telephone Company, Inc.
  Michigan Bell Telephone Company
  The Ohio Bell Telephone Company
  Wisconsin Telephone Company

- **Bell Atlantic**
  New Jersey Bell Telephone Company
  The Bell Telephone Company of Pennsylvania
  The Diamond State Telephone Company
  The Chesapeake and Potomac Telephone Company
  The Chesapeake and Potomac Telephone Company of Maryland
  The Chesapeake and Potomac Telephone Company of Virginia
  The Chesapeake and Potomac Telephone Company of West Virginia

- **BellSouth**
  South Central Bell Telephone Company
  Southern Bell Telephone and Telegraph Company

- **Nynex**
  New England Telephone and Telegraph Company
  New York Telephone Company

- **Pacific Telesis Group**
  The Pacific Bell Telephone and Telegraph Company
  Nevada Bell

- **Southwestern Bell Corporation**
  Southwestern Bell Telephone Co.

- **US West**
  The Mountain States Telephone and Telegraph Company
  Northwestern Bell Telephone Company
  Pacific Northwest Bell Telephone Company