are primarily intrastate in nature and subject to rate regulation by the various state regulatory agencies. Hence, there is no standard rate structure, making rate comparisons between different LECs a much more difficult task.

In addition to summarizing the technical characteristics of the interconnection types, and the regulatory considerations, this report also describes some of the interconnection principles that are usually incorporated in the interconnection agreements as well as explains the rate elements that are often the basis for the rates themselves. Actual rates from 59 different locations, representing at least one city from each state plus Puerto Rico, were compared using an identical topology for each location. The rates were from 15 different companies, including each of the seven Regional Bell Operating Companies (RBOCs), GTE, and Sprint.

The vast majority of the interconnection rates are based on a minutes-of-use (MOU) charge for mobile-to-land traffic. But the rates cannot be adequately compared based on the MOU charge alone because there are other factors that are often added to the rates. These include charges for facilities to connect the wireless location to the appropriate LEC end office or tandem office plus charges for equipment in those respective offices. So the rate comparisons evaluated the three basic types of interconnection (Type 1, Type 2A, and Type 2B) in terms of the basic usage rate as well as a total usage rate. In addition, an average charge for the digital DS1 facilities was computed for each location.

Finally, there has been considerable controversy over the cost of activating numbers for wireless services. Like the interconnection rates, there is a wide variation in the charges for activating numbers. The report details the charges for activating an entire NXX code (10,000 numbers) and charges for activating a block of 1,000 numbers.

2.0 Executive Summary

Because the number of wired telephone lines in the United States is approximately five times greater than number of subscribers of the largest wireless service (cellular), it is essential that wireless carriers have access to this large set of landline users.

2.1 Technical Considerations

A number of different types of interconnection arrangements are available and these are described in Bellcore's Technical Reference TR-NPL-000145, which is more commonly known as TR-145. Briefly, these alternatives, which are illustrated in Figure 3.1, are as follows:

Dial Line:	A line side connection like your home or business telephone.
DID:	A one-way trunk-side connection using reverse battery supervision.
Type 1:	A one-way or two-way trunk-side connection from an end office that uses E&M supervision.
Type 2A:	A one-way or two-way trunk-side connection from a tandem office that uses E&M supervision.
Type 2B:	A one-way or two-way trunk-side connection from an end office that uses E&M supervision and is used as a high-usage trunk in conjunction with a Type 2A.
Type 2C:	A one-way or two-way trunk-side connection from a 911 tandem office that uses E&M supervision and is used for 911 traffic.
Type 2D:	A one-way or two-way trunk-side connection from a LEC's operator services tandem office that uses E&M supervision and is used for operator services traffic.
Type "S":	A 56 kbps link used for connection to a location in a Common Channel Signaling (CCS) network that uses Signaling System 7 (SS7) protocols.

ISDN-BRI: A basic rate (2B+D) ISDN connection from an end office.

ISDN-PRI: A primary rate (23B+D) ISDN connection from an end office.

Although LECs are not obligated to provide any or all of the interconnection types listed in TR-145, most generally comport with the technical descriptions of the interconnection types they do provide. U S WEST Communications generally conforms with TR-145 but its methodology is different from the other RBOCs in that it has essentially established sub-categories for Type 2A and Type 2B service.

In addition to the technical arrangements, numbers are almost as crucial to wireless carriers as radio spectrum. These numbers are currently administered by the LECs and obtaining numbers has not always been easy. Rulings by the Federal Communications Commission (FCC) and industry agreements have mitigated a number of these problems but the industry is still negotiating new intervals for activation periods and other issues.

2.2 Regulatory

Since 1949, the FCC has issued a number of rulings pertaining to wireless/wireline interconnection. Each of these rulings has expanded previous rulings and have resulted in some fundamental principles which include:

(1). Wireless carriers are co-carriers, not end users. They deserve to be treated like other carriers instead of like a subscriber.

(2). LECs must provide tandem (Type 2) interconnection, if requested, and the LECs cannot offer an arrangement that favors their subsidiary.

(3). The FCC has not mandated any particular form of interconnection but has stated that the interconnection agreement must be negotiated in good faith between the parties.

(4). Mutual compensation, which is addressed as a principle in Section 5, is appropriate for certain interconnection arrangements.

(5). The LECs do not "own" telephone numbers and the FCC has plenary jurisdiction regarding numbering disputes.

(6). States cannot regulate the rates charged to subscribers of wireless services.

(7). States have jurisdiction regarding compensation matters although the FCC can preempt a state if the rates are so onerous as to prohibit competition.

(8). Wireless carriers do not have to file tariffs for any interstate rates.

In December, 1995, the FCC issued a Notice of Proposed Rulemaking (NPRM) regarding interconnection policies with respect to compensation between LECs and wireless carriers. It has tentatively concluded that information regarding interconnection arrangements should be made publicly available. The FCC is seeking further comments on three alternatives regarding implementation of interconnection policies. These are; (1) a federal policy that would directly govern interstate services and serve as a model for states to regulate intrastate services, (2) a federal mandate that would set general parameters which would allow states a range of implementation choices, or (3) specific federal requirements for interconnection that would apply both to interstate and intrastate interconnection. The FCC has proposed an interim "bill and keep" arrangement whereby each carrier would reciprocally terminate calls on its network without charge to the originating network.

Because the states currently have the right to regulate interconnection rates, they are a powerful regulatory force. The states cannot ignore an FCC policy except in cases where compensation is an issue. For example, the states cannot prohibit a LEC from offering a Type 2 connection but the state can approve the rate that is charged for a Type 2 interconnection.

Although the FCC preempted the states regarding the right to regulate prices charged by wireless carriers to subscribers, there still remains unresolved issues with respect to entry requirements.

Some states have chosen not to regulate interconnection rates and simply leave it to the parties for negotiation. Others want to be informed of the results of the negotiation, but do not approve the rates. Still others insist on approving any rates that are negotiated.

A number of interconnection principles have been established over the years by the FCC and other regulatory bodies. Included in these have been the principles of co-carrier status, good-faith negotiation, and mutual (or reciprocal) compensation. Other principles, such as rate stability or confidentiality clauses, are negotiated individually.

2.3 Rate Elements

The rates in an interconnection agreement are often based on the cost-based rates used in the LEC's Access Services tariffs. These rates contain a number of rate elements but not all of these elements are generally used to determine the rates for a wireless/wireline interconnection agreement. However, there is no national standard as to which elements must be included or excluded from the interconnection rates that are ultimately negotiated.

Rate elements from the Access Services tariffs are often used by the LECs to establish rates for wireless interconnection because the rates are cost-supported and it helps the LEC maintain parity between services offered to ICs and those offered to wireless carriers. While these services may have different nomenclature, there are many similarities in terms of operation.

There are two basic types of access services, switched access and special access. Switched access covers services that are actually switched by the LEC while special access are private lines having telegraph, voice-grade, digital, video, or audio transmission characteristics.

Switched access is comprised of Local Transport, End Office (Local Switching), Residual Interconnection Charge, Chargeable Optional Features, and Common Line rate categories. Figure 6.1 illustrates these access rate elements and the specific elements are discussed in the following paragraphs.

For mobile-land usage rates, a typical interconnection agreement that uses access charges as a basis may include the Entrance Facility, Local Transport, End Office, and Residual Interconnection Charge elements. The Local Transport portion is usually based on the Tandem Switched Transport rates while the End Office may include only the Local Switching Charge. Usually, the Common Line charges are excluded and often the Information Surcharge element is also not included in the total wireless interconnection rate.

Special access services offer a number of facilities with different transmission characteristics and are used for a variety of purposes. There are a number of rate elements that can be included for special access services but the elements that are typically included in a wireless/wireline agreement are the same as those used for a two-point private line service. These two-point private lines may be a voice-grade analog channel but more

frequently are digital facilities at the DS1 (24 voice-grade equivalent channels) or DS3 rate (672 voice-grade equivalent channels). The three rate elements for these circuits are Channel Termination, Channel Mileage Terminations, and Channel Mileage Facility charges.

All three of these special access rate elements are often included in rates for wireless/wireline interconnection. The terminology may vary because some of the LECs use rates from their Private Line tariffs, which resemble special access but do not always use the same terminology.

Rates charged by the LECs recover the basic cost of the component plus provide a profit for the LEC. But most of the rates charged by the LECs also contain a Contribution element which is an additional charge added to the rate that is used to support local exchange service. This extra charge can range from 10% to 3000% with 40-50% being a typical amount.

Each LEC included in the study has its own rate structure for wireless/wireline interconnection arrangements. As a matter of illustration, only the rate structures of those LECs owned by the Regional Bell Operating Companies (RBOCs) are described in the study. Furthermore, only the rate structures for determining the monthly recurring charges for Type 1 and Type 2A interconnections are described. Most of the LECs, but not all, use a different rate structure for Type 1 service than Type 2A. Moreover, while the rates for both types of connections may be based on access service elements, it is not always clear which elements have been included in the final rate. In addition, the nomenclature that is used is by no means identical between the various LECs.

As shown in Figures 6.3 and 6.4, Ameritech uses different rate structures for Type 1 and Type 2A connections. Also these structures are not entirely consistent throughout the five Ameritech states. Type 1 charges usually only consist of a facility charge plus normal

message unit charges. Type 2 uses some access elements but the nomenclature is different, such as Dedicated Channel Charge (CDC) and Dedicated Trunk Transport (DTT). The rate structure for Type 2 has both mileage and usage-sensitive elements which results in a lower usage rate than Type 1.

Bell Atlantic uses some access service rate elements for both Type 1 and Type 2A but the rate structures are not the same for the two types of connections. The rate structures, which are depicted in Figures 6.4 and 6.5, are fairly consistent throughout Bell Atlantic's seven jurisdictions. Like Ameritech, Bell Atlantic has message unit charges for Type 1 instead of a minutes-of-use charge. For most of Bell Atlantic, there are no separate facility charges for Type 2. Instead the cost of the facilities is included in the usage charge, and the total charge for Type 2 is still considerably less than Type 1.

BellSouth uses the same rate structure for both Type 1 and Type 2A connections. Essentially, a Connecting Facility charge using common DS1 rate elements, Channel Termination and Channel Mileage, is used from the POI to the end office (Type 1) or access tandem (Type 2A). A fixed Digital Trunk Termination charge is used to recover the cost of terminating the DS1 facility into a switch at the end office (Type 1) or access tandem (Type 2A). In addition, except for Florida and Louisiana, BellSouth imposes a fixed Control Access Register charge which BellSouth says is used to recover non-traffic sensitive costs in those offices. Finally, a fixed MOU rate is used, which in most of the states, provides LATA-wide coverage for mobile-land calls.

Different rate structures are used by Nynex for Type 1 and Type 2A connections. In addition, there is considerable variation in rate structures between the five different states for both types of connections. Figures 6.9 and 6.10 depict the rate structures in Massachusetts. Type 1 typically has facilities charges and message units. Except for New York, the message unit charges generally provide five minutes of conversation for one message unit. Consequently, in the majority of Nynex states, a rate anomaly results in that

rates for Type 1 are cheaper than those for Type 2A for a typical two-minute wireless call. For Type 2, most of the Nynex states use various access rate elements although Maine and New York simply use a single MOU rate. There is no facilities charge associated with Type 2 connections.

Although the rates themselves are different, Pacific Bell uses similar rate structures for Type 1 and Type 2A. The rate structure includes facility charges and the usage rate includes both per-message as well as per-minute-of-use components. Access rate elements are used as a basis for these rate elements. Pacific Bell also offers term pricing options that provides reduced usage rates if certain traffic volumes are exceeded over a three year period.

Similar to BellSouth, SBC Communications uses an identical rate structure for both Type 1 and Type 2A connections that consists of a facility charge and an MOU charge. However, unlike most of BellSouth, SBC Communications has a lower rate for Type 2A than Type 1. In addition, SBC Communications provides a discounted facilities rate for two-way or terminating-only facilities in recognition of the fact that the wireless network is terminating a percentage of traffic on the wireless network. Usage rates for SBC Communications are based on minutes-of-use. There is no identification of any access service elements in the rates that are quoted. Type 2A rates are typically about 20% cheaper than Type 1 rates.

Different rate structures are used by U S WEST Communications for Type 1 and Type 2A but U S WEST Communications has been very successful in achieving almost identical rates and rate structures throughout its fourteen state territory. These different rate structures also result in Type 2A being cheaper than Type 1 connections. Both Type 1 and Type 2 rate structures have separate facility charges and utilize access rate elements.

2.4 *Interconnection Rates*

Interconnection rates can be a significant expense for a wireless carrier but comparing rates between different locations can be difficult. This is primarily because of the number of variables involved in the process which includes the cost of facilities to link the wireless location with the LEC office for interconnection, the rate elements included in the usage rate calculation, and the calling scope provided by the quoted usage rate.

In order to provide a standard type of arrangement for comparison purposes, MTA-EMCI used the same basic configuration for each location. This configuration, which is shown in Figure 7.1, includes Type 1, Type 2A, and Type 2B switched interconnection arrangements plus private lines to connect two remote cell sites back to the Wireless Switching Center (WSC).

A comparison was made of the interconnection rates in at least one city in each of the 50 states plus Puerto Rico. Puerto Rico was included because the Federal Communications Commission (FCC) has the authority to issue radio licenses in Puerto Rico and approve interstate interconnection rates.

Data for interconnection rates from a total of 59 different locations involving 15 different LECs was gathered and analyzed. While a number of the interconnection rates are contained in tariffs filed by the LECs, there are also a number of contractual arrangements for interconnection. Complete copies of the contractual arrangements were not available but the LECs did provide pricing information suitable for comparison purposes.

The specific locations and LECs that were used in the study are shown in Table 7-1.

Basic usage rates are strictly the usage rate components and do not include additional charges such as facility or trunk termination charges. A Total Usage Rate is computed when these components are added to the Basic Usage Rate.

As shown in Chart 7A, there is a tremendous range of Basic Usage Rates for Type 1. The average value is $0.047463 with a standard deviation of $0.028378. The median average is $0.037. Las Vegas, Nevada, has the lowest Type 1 Basic Usage Rate at $0.016286 while Nashua, New Hampshire, has the highest rate at $0.159 per minute of use.

Type 2A Basic Usage Rates average $0.026923 per minute of use with a standard deviation of $0.010632. The median value is $0.0245. San Juan, Puerto Rico, has the highest rate at $0.07 and Dallas, Texas, has the lowest rate at $0.012442.

Chart 7C shows the Type 2B Basic Usage Rates with a mean average of $0.022346 and a median average of $0.0206. The standard deviation is $0.012054. The highest Type 2B Basic Usage Rate is again found in San Juan, Puerto Rico, and it is identical with the Type 2A rate of $0.07. Chicago, Illinois, has the lowest Basic Type 2B rate at $0.0064.

As previously explained, the basic architecture used DS1 facilities to connect the Type 1, Type 2A, Type 2B, and provide private lines from the Wireless Switching Center (WSC) to the cell sites. For all locations, the mean average was $0.018548 per foot with a standard deviation of $0.006154. The median average was $0.016307. San Juan, Puerto Rico, had the highest DS1 rates at $0.043486 per foot while the lowest rate is $0.009745 in Reno, Nevada. These results are shown in Chart 7D.

Chart 7E depicts the Total Type 1 Usage Rate which has a mean average of $0.050957 with a standard deviation of $0.029866. The median average is $0.039591. Nashua, New Hampshire, still had the highest rate but it increased to $0.163766 because of the facility

and trunk charges. Dallas, Texas, edged out Reno, Nevada, for the lowest rate at $0.018941. This was primarily due to the trunk charges for Reno.

Total Type 2A Usage Charges, as shown in Chart 7F, have a mean average of $0.028767 and a standard deviation of $0.01074. Not surprisingly, San Juan, Puerto Rico, had the highest rate since San Juan also had the highest rate for both the Type 2A Basic Usage Rate and the highest DS1 price per foot. The lowest Total Type 2A rate is found in Dallas, Texas, at $0.014359.

Many locations, but not all, have lower rates for Type 2B than Type 2A. Chart 7G shows the mean average Total Type 2B rate as $0.024901, which is slightly lower than the rate for Type 2A. The standard deviation is $0.011872 while the median average is $0.021974. Once again, San Juan, Puerto Rico, has the highest rate at $0.076021. The lowest rate is Milwaukee, Wisconsin, whose rate is $0.007746.

Of the approximately 160 million access telephone lines in the United States, about 80% are served by the RBOCs. Also, in this study, 48 of the 59 locations, or 81%, were RBOC locations. Because the RBOCs are such a significant portion of the industry and this study, it is interesting to see how they compare to each other. While GTE is as large as the RBOCs, it was not included because only three GTE locations were used in the study. Table 7-5 below summarizes how the RBOCs rank in each of the seven categories used for the individual locations.

As shown in Table 7-3, there is a tremendous range of charges for activating an entire NXX code (10,000 numbers). Some LECs charge absolutely nothing while others charge as much as $30,600 to activate an entire NXX code. The average cost is $3,738 for all of the surveyed locations.

Similar to charges for activating an entire NXX code, there is a large disparity between LECs regarding the monthly charges for blocks of numbers from a shared NXX code. These charges range from zero to $0.5295 per number, per month, and the mean average charge is $0.093063 per number, per month.

2.5 Conclusions And Future Trends

Telecommunications in the United States, particularly the wireless segment, is a rapidly growing and changing industry. These changes are the result of technological, regulatory, and market forces which will continue to influence growth and change for the foreseeable period.

A number of new interconnection arrangements were added to TR-145 in December, 1993, as the result of industry negotiations that took place beginning in 1991. Not all LECs offer all of the interconnection types but gradually it is expected that more LECs will offer the full array of interconnection types described in TR-145. Specifically, the Type "S" connection, which is used for SS7 links, will be offered by more LECs because wireless carriers want the benefit of SS7 interconnection. The Wireless Interconnection Forum (WIF), which produced the revised TR-145, is presently trying to determine if any further revisions are required.

It is still too early to determine whether the FCC will preempt the states regarding regulating interconnection rates. In its December, 1995, decision, the FCC proposed a "bill and keep" solution in which carriers would terminate traffic on their respective networks without charge to the originating carrier. Each carrier would keep all of the revenue for originating traffic. The FCC is seeking comments on several alternatives that range from simply providing guidelines to complete federal control over interconnection

rates. This docket will probably not be settled quickly but, regardless of the outcome, will affect the compensation arrangements between wireless and wireline carriers.

States have already been preempted with respect to regulating rates charged to customers by wireless carriers. Some have sought to impose regulation through control over certification proceedings and other market entry regulations. Such actions may also affect interconnection rates, at least in the short term. States are also taking the lead on number portability issues which may also affect interconnection rates.

Over the last decade, the trend in interconnection rates has been one of declining prices. This trend will not only continue but will probably accelerate due to regulatory actions and the inexorable drive for local loop competition.

Interconnection rates have often been based on rate elements used for access services. These access rate elements should continue to decline and, for those companies whose rates are almost entirely based on access rate elements, will likely result in lower interconnection rates.

Some LECs have broken the link between access rate elements and interconnection rates and have substituted negotiated rates. Where this substitution has occurred, lower interconnection rates have resulted.

Parity between rates charged to different carriers, however, is not always easily defined. Competitive Local Exchange Carriers (CLECs) have negotiated interconnection rates with the LECs. These rates, which are usually approved by the state regulatory agency, are sometimes lower than the rates charged to wireless carriers. A goal of the wireless carriers is to achieve parity with the CLECs but doing so may require acceptance of additional regulatory burdens from a state. Compromises may be needed but achieving this goal of parity should result in lower interconnection rates for the wireless carriers.

Finally, the FCC's NPRM in Docket 95-185 addressing compensation arrangements will almost assuredly result in lower interconnection rates. The FCC's proposed "bill and keep" solution would basically eliminate usage-based interconnection charges. CTIA believes that interconnection revenues from wireless carriers for LECs in 1994 was about $800 million. This is very close to the conservative estimate by MTA-EMCI of $816 million for the same period. Based on estimated 1996 wireless revenues, MTA-EMCI estimates LEC interconnection revenues should be about $1.309 million. In any event, this is a large revenue stream for the LECs to lose.

As alternatives to "bill and keep," the FCC is also seeking comment on using bill and keep for off-peak usage only, using a subset of access rate elements, using other interconnection rates as a basis for wireless rates, or adopting a uniform per-minute interconnection charge. All of these alternatives should result in lower interconnection rates for wireless carriers.

3.0 Technical Considerations

Wireless and wireline networks must be physically interconnected in order to exchange traffic with each other. It is also possible for wireless networks to be connected with each other but that is not in the scope of this document.

In addition to the various technical types of interconnection, there are also choices to be made regarding the type of facility that is used to transport the interconnection. These choices involve several varieties of analog, digital, and optical interfaces.

Numbering resources is almost as important as radio spectrum to a wireless carrier. Obtaining numbers has not always been easy for wireless carriers but the

telecommunications industry has reached some agreements within the past few years which has helped mitigate some of the issues.

3.1 Types Of Interconnection

While the FCC has never mandated any particular form of interconnection, it has agreed that the types of arrangements used should be negotiated by the carriers themselves. There are a number of possibilities for interconnection arrangements and the telecommunications industry added several new types in 1993 when the revised edition of Bellcore's Technical Reference TR-NPL-000145, "Compatibility Information for Interconnection of a Wireless Services Provider and a Local Exchange Carrier Network" was issued. This document, commonly known as TR-145, was issued by Bellcore after many discussions with the industry through the auspices of the Wireless Interconnection Forum (WIF), an industry group that discusses wireless interconnection issues.

Wireless carriers generally do not use all of the interconnection types described in TR-145 nor do the Local Exchange Carriers (LECs) always offer the full array of interconnection types. But accommodations may be made by the LECs when a particular type is ordered even if it was not initially offered as an alternative.

Figure 3.1 provides a schematic diagram of the various interconnection possibilities.

3.1.1 Type 1

Type 1 is the original interconnection proposed for cellular carriers. It was originally called a TA-76 connection because it was first described in an AT&T document called Technical Advisory #76 but was changed to Type 1 when TR-145 was first issued in 1986.

Type 1 is a trunk-side connection from an end office but through special translations in the switch, which are often referred to as Trunk With Line Treatment (TWLT), is able to perform certain line-side features. Not all switch types can provide two-way Type 1 connections but it is possible with the 1AESS, 5ESS, DMS-100, as well as the GTD5. Type 1 uses trunk protocols and is restricted to multifrequency (MF) address pulsing and E&M supervision. It is normally used as a two-way trunk but can be configured for one-way use.

Presubscription to a Primary InterLATA Carrier (PIC) is applied on a trunk group basis with the wireless carrier selecting the Interexchange Carrier (IC).

There are no call-type restrictions placed on traffic that can be carried over a Type 1 connection as it provides access to all valid NXX codes, N11 codes, N00 codes, and operator services.

Either shared or dedicated NXX codes may be used with a Type 1 connection and the codes are shown in the Local Exchange Routing Guide (LERG) as residing in the end office providing the Type 1 connection.

3.1.2 Type 1 Variation (ISDN)

A variation of Type 1 connection is the use of an ISDN connection at either the Basic Rate Interface (BRI) or Primary Rate Interface (PRI). The difference is the ISDN-BRI offers two bearer channels plus one data channel (2B+D) while the ISDN-PRI uses 23 bearer channels and one data channel (23B+D). ISDN connections are possible only from offices equipped with special generics.

All other factors, such as call types permitted, NXX codes, and presubscription are similar to the conventional Type 1.

3.1.3 Type 2A

Type 2A connection is used between a Wireless Switching Center (WSC) and a LEC tandem. This tandem is usually an Access Tandem but Type 2A is used in some LEC networks to provide a separate connection to a Local Tandem when the Local Tandem function is separated from the Access Tandem. In some LEC networks, the Local Tandem function already exists while in others the capability is created in an existing end office using translations that are a normal part of modern digital switching machines.

Type 2A trunks are not available from all switch types but can be provided from the 1AESS, 4ESS, 5ESS, DMS-100 (for local tandem only), DMS-200, or GTD5. Type 2A connections from other switch types are possible but Automatic Message Accounting (AMA) recordings may not be possible. Type 2A trunks are trunk-side connections usually restricted to multifrequency (MF) address pulsing and E&M supervision when inband signaling is utilized. Most Type 2A trunks are two-way although one-way trunks are also possible.

There is no presubscription with a Type 2A trunk because equal access, if provided, is the responsibility of the wireless carrier.

Normally only dedicated NXX codes are used with Type 2A connections. There is no standard for portraying these NXX codes in the LERG although the majority of LECs now use Vertical and Horizontal (V&H) coordinates of the Point Of Interface (POI), which may not necessarily be the WSC location. Other LECs will use the V&H

coordinates of their tandem office for this purpose. While it is technically possible to use a shared NXX code for Type 2A connections, it is not a common practice.

3.1.4 Type 2B

While traffic terminating or originating over a Type 2B is restricted to NXX codes within the specific end office used for the Type 2B connection, it can be a very useful connection for wireless carriers. The Type 2B connection usually functions as a high-usage trunk between a WSC and a specific end office in the LEC network. It is used in conjunction with a Type 2A such that the first routing choice is the Type 2B with overflow capability via the Type 2A.

Type 2B connections can be provided with the same switch types that are used for Type 1 connections, i.e., 1AESS, 5ESS, DMS-100, and the GTD5. Other switch types may be used but AMA recordings may not be possible. Like the other trunk-side connections, these trunks use MF address pulsing with E&M supervision when inband signaling is used and may be configured for one-way or two-way service.

There is no presubscription with Type 2B because there is no access to ICs via Feature Group D (FGD) over a Type 2B and the NXX code is associated with the Type 2A connection.

3.1.5 Type 2C

Although 911 calls can be processed via the Type 1 or Dial Line connections, another alternative is the use of the Type 2C connection. None at present can identify both the mobile telephone number as well as provide location identity. There are several different

options with Type 2C and the exact configuration depends on the LEC as well as the Public Safety organization responsible for emergency calls. One possibility is to directly connect to the 911 tandem while others are essentially a modified Type 2A.

The direct connection variety uses specific telephone numbers to identify a particular cell site or a sector of a cell site. The mobile telephone number cannot be used because the Public Safety Answering Point (PSAP) usually does not have a record of the mobile subscriber. Moreover, this Type 2C option can cause the screen at the PSAP to flash by inserting an extra digit into the address pulsing stream.

A modified Type 2A is another alternative. In this configuration, the WSC translates the 911 digits that were dialed by the mobile user into a 7-digit telephone number that either represents the cell site or rings at a special location at the PSAP. This special number is then forwarded over a special trunk group to the Access Tandem, which then forwards the digits to the 911 tandem.

These trunks are normally one-way, trunk-side connections that use MF address pulsing and E&M supervision for inband signaling applications.

3.1.6 Type 2D

As another alternative to routing operator services traffic over a Type 1 connection, the Type 2D connection provides a direct link between a WSC and a LEC's Operator Services Position. This Position is actually a tandem switch with operator services call processing capabilities.

The use of a Type 2D trunk also allows the LEC to provide services such as Directory Assistance Call Completion (DACC) whereby the LEC can transfer a call to the desired

number after the caller has been informed of the proper number by the Directory Assistance operator. This is not possible with a Type 1 connection because the LEC does not receive the actual Automatic Number Identification (ANI) of the mobile unit over the Type 1 connection.

ANI over a Type 2D is possible by using a different signaling protocol called Operator Services Signaling (OSS). Two different types of OSS protocols are possible with the difference mainly being whether the ANI consists of 7 or 10 digits. In any event, the software at the WSC generally has to be changed to provide either type of protocol.

Type 2D connections are trunk-side connections using MF address pulsing and E&M supervision for inband signaling. They are normally configured for one-way service but can be two-way.

3.1.7 Type "S"

For the trunk-side connections described in the previous paragraphs, inband signaling with MF address pulsing and E&M supervision is quite typical. However, out-of-band signaling using a Common Channel Signaling (CCS) arrangement has some significant advantages, such as reduced trunk requirements and the ability to receive caller identification. For this reason, the Type "S" connection was developed to allow the use of a CCS arrangement that used the Signaling System #7 (SS7) protocol.

Type "S" is particularly useful with Type 2 connections (2A, 2B, 2C, & 2D), as has been shown in industry trials. Further work is necessary to determine if Type "S" has any applicability with Type 1 connections.

Type "S" is a standard 56 kbps link that is used for SS7 signaling purposes. It may be used to link the WSC to a LEC's Signal Transfer Point (STP), or to link a wireless carrier's STP to a LEC's STP, or to link a wireless carrier's STP to a LEC's Service Control Point (SCP).

Precisely which types of SS7 messages are exchanged over the Type "S" connection is a matter of negotiation. It is particularly preferable to use the ISDN-User Part (ISDN-UP) and Transaction Capabilities Application Part (TCAP) portions of the SS7 protocol. Call set-up functions are provided by the ISDN-UP messages while the TCAP messages are used for database queries.

3.1.8 Direct Inward Dialing (DID)

Used for many years by paging carriers and two-way mobile providers, DID connections are one-way trunk-side connections that outpulse the digits of the called number to the carrier. These connections may be provided by most any end office switch type. While many carriers would prefer to have MF address pulsing with a DID connection, a number of LECs restrict the address pulsing options to either Dial Pulse (DP) or Dual Tone Multifrequency (DTMF). DP is analogous to rotary dial while DTMF is the same as touch-tone service. There is no technical reason why MF address pulsing cannot be provided when modern digital switches such as a 5ESS or DMS-100 are used in the LEC network.

3.1.9 Dial Line

Unlike the other switched type connections that have been discussed, Dial Line connections are line-side connections like those used for normal residence or business line

applications. There are generally no restrictions as to the types of calls that may be processed over the Dial Line connection but they do not use trunk-side signaling protocols which means they do not provide certain essential features, such as answer supervision and MF address pulsing, that are available with other connection types. Typically, Dial Line connections employ loop supervision with DP or DTMF address pulsing.

3.1.10 Private Lines

Wireless carriers often use private line connections provided by the LEC to link cell sites to the WSC, link different WSCs together, or to connect remote transmitter sites. These private lines vary in capacity and capabilities. These same types of private lines are also often obtained from providers other than the LEC.

Analog facilities are still used by some wireless carriers although the price of digital facilities has made analog less attractive if quantities over five circuits or so are required. Analog facilities provide a voice-grade transmission path (300-3000 kHz) and may be provided on a two-wire or four-wire basis.

Digital facilities have become less expensive and more prevalent in the LEC network in recent years. These circuits may be provisioned at the DS0 (64 kbps), DS1 (1.544 Mbps), and DS3 (45 Mbps) level. Bit compression techniques can be employed on digital private line links to increase capacity, such as 48 voice channels instead of 24 voice channels on a DS1 facility. However, bit compression cannot be used if the private line link is actually a trunk into the switched network, such as that used to connect a WSC to a LEC tandem.

Fiber facilities are also used by wireless carriers, particularly for microcell locations where microwave is not available and ordinary digital circuits, like DS1 or DS3, are not suitable. A number of LECs have refused to offer fiber facilities unless the LEC owns all of the

terminating equipment at both ends, or at least one end, of the circuit. Other LECs have taken a more enlightened approach and offer either an electrical or an optical interface for a fiber facility.

Some LECs are just beginning to offer Synchronous Optical Network (SONET) interfaces at the OC-1 (51.840 Mbps), OC-3 (155.520 Mbps), OC-12 (622.080 Mbps), and OC-48 (2488.320 Mbps) levels.

3.2 Point Of Interface (POI) Considerations

Often the Point Of Interface (POI) is the same location as the WSC but it can be located in a variety of other places, such as a cell site, an IC's Point Of Presence (POP), or a leased space in a building. There is no valid reason why it cannot be a location other than the WSC as long as the wireless carrier provides the necessary space, and if necessary, power, for any required LEC equipment.

The type of interconnection ordered by the wireless carrier should not affect the interface type that is used unless the physical facilities, such as those needed for DS3 service, are not available. While a typical arrangement might include Type 2A connections using a DS1 interface, there is no reason why a wireless carrier could not have DID connections using a DS1 interface if that was their preferred arrangement.

Analog and DS1 digital interfaces may use a number of different physical facilities, such as copper wire, fiber, or radio, to provide the desired interface. DS3 interfaces can only be provided via fiber or radio facilities.

For optical interfaces, it is recognized that unless a SONET interface is used, the terminating equipment must be the same for both ends of the facility.

3.3 Comportment With Technical Reference TR-145

Bellcore's TR-145 describes the general technical characteristics associated with each type of interconnection. This Technical Reference is cited as a reference by most of the LECs in their tariffs, contracts, or other information. While there is no obligation for a LEC to provide all of the types of interconnection noted in TR-145, most of the LECs are at least offering Type 1, Type 2A, and Type 2B. All of the seven Regional Bell Operating Companies (RBOCs) indicate that their offerings comport with TR-145 and they do, given their latitude to deviate from precisely following TR-145. But the manner in which these deviations occur differs between the RBOCs.

Ameritech, Bell Atlantic, BellSouth, Nynex and SBC Communications appear to comply with all of the provisions of TR-145 regarding Type 1, Type 2A, and Type 2B. They place no restrictions on the types of traffic that can be handled by each of the interconnections, other than those already listed in TR-145. Nor do these five companies require any segregation of traffic types for a given type of interconnection.

Pacific Bell also adheres to TR-145 except that it does not permit the routing of calls to Service Access Codes (500, 700, 800, or 900) over Type 2A connections. Pacific Bell requires these types of calls to route via a Type 1 connection.

U S WEST Communications generally conforms with TR-145 but its methodology is different from the other RBOCs in that it has essentially established sub-categories for Type 2A and Type 2B service. For example, separate offerings are described for Type 2A to a local tandem, a toll tandem, and an "ancillary" trunk group. The ancillary trunk group is a one-way trunk used for Operator Services and is actually the equivalent of a Type 1 connection since it routes to an end office instead of a tandem. Type 2B is offered as a