555-035-810
Issue 1, January 1992

DEFINITY® Communications System

World Class Routing

Application Notes

Acknowledgments
Developed by the AT&T Bell Laboratories Systems Engineering Center in Lincroft, New Jersey.

Notice
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World Class Routing

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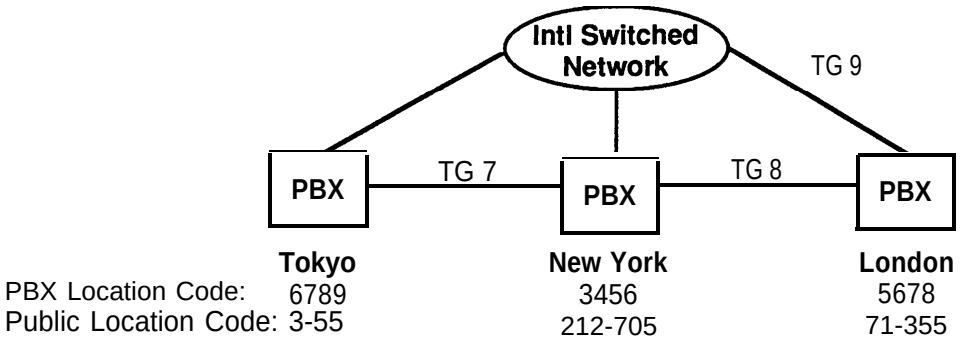
Overview

World Class Routing (WCR) is a new feature on the DEFINITY Communications System Generic 2.2 and Generic 3 that provides enhanced digit analysis capabilities to the Automatic Route Selection/Automatic Alternate Routing (ARS/AAR) and Toll Restriction features. With private networks becoming larger and going global, customers must develop networks with sophisticated numbering plans that take into account more locations, domestically and internationally. WCR provides this capability by eliminating past numbering plan constraints and allowing network administrators much greater flexibility in defining both North American and international private numbering plans. These enhancements are provided through new algorithms that allow for more flexible digit analysis.

WCR lends itself to many domestic and international applications through some of the following enhancements:

- **Flexible dialing lengths up to 31 digits** — International locations are not limited to the 7 and 10 digit formats used in the U.S. and often vary in length. WCR allows for the inclusion of international locations into private numbering plans and can be used to expand current numbering plans.
- **M to N Digit Conversion** — Prior releases of DEFINITY provided 10 to 7 digit conversion. However, with WCR a DEFINITY can identify up to 31 (M) digits and then replace up to 31 (N) digits. International gateways can take advantage of this capability by converting international public calls to private network calls.
- **Flexible Digit Analysis** — No longer will calls have to be routed solely on the RNX of the dialed number. Instead, calls can be routed on any combination of up to 18 digits and/or the length of the dialed number. Wild card digits, digits in which no particular number is specified, can also be used in the M to N Digit Conversion Tables, AAR/ARS Routing Tables, and Unrestricted/Restricted Calling Tables to provide even greater flexibility.
- **Subnet Trunking** — Once a routing pattern has been selected, WCR enables the DEFINITY Generic 2.2 to modify the digits by deleting up to 31 digits and then inserting up to 31 digits. The DEFINITY Generic 3 can delete up to 18 digits and insert up to 36 digits.
- **Compatible with existing translation tables —** The administration of WC-R translations is provided through new procedures and tables. However, WCR still supports translations that were entered in earlier releases of DEFINITY allowing for simple upgrade procedures.

The following pages describe several applications that take advantage of WCR. The use of WCR, however, is *not* limited to these applications. It is the intent of these notes to give readers an understanding of the capabilities and benefits of WCR via these applications so that they can tailor this feature to their own applications and needs. Furthermore, the diagrams and tables shown in these notes depict, conceptually, how these features work and are not intended to describe how this feature is administered. More detailed information concerning the operation and implementation of WCR can be found in the appropriate feature description manuals and implementation guides.



ARS M to N Digit Conversion - London

Dialed String	Replace
0101212705	3456
01081355	6789

AAR Digit Analysis Table - London

Dialed String	Min	Max	Routing Pattern
3456	8	8	1
6789	6	8	2

Routing Patterns - London

	Preference	Trunk Group Number	Number Deleted Digits	Inserted Digits	Comments
Pattern #1:	1.	8	0	0	*Route over Pvt Line*
	2.	9	4	0101212705	*Route over Intl Switched Network*
Pattern #2:	1.	8	0	0	*Tandem through New York*
	2.	9	4	01081355	*Route over Intl Switched Network*

Figure 1. International Networking

International Networking

Multinational customers with WCR can have much greater flexibility in routing their international traffic. WCR allows the PBX to route international calls based upon the length of the dialed string and any set of digits within that string. For example, a U.S. multinational may have offices in Tokyo, New York, and London that are connected together in a private network. Calls from any of those locations to any other will be carried over the private network, while all other calls will be handled by the public network.

Figure 1 shows how this company can benefit from WCR. With the network shown in Figure 1 and assuming that each site has a DEFINITY PBX with WCR, an employee in the London office calls the New York office by dialing 9 to invoke ARS followed by 01012127050000. 010 is the international access code in the UK (similar to 011 in the US), 1 is the country code for the U.S. and the remaining ten digits represent the called party's number. In this case, the destination is an endpoint on the private network and the call should therefore be routed using AAR over Trunk Group 8.

To do this, M to N digit conversion is done to convert the public number into a private number by replacing 0101212705 with the PBX location code 3456. Note that the PBX location code is no longer limited to the three digit format as used in the past — routing decisions with WCR can be performed on any set(s) of digits. In this example, an arbitrary length of four digits was chosen for demonstration purposes.

With M to N digit conversion completed, the London PBX must select a Routing Pattern to handle the call. This is done using the AAR Digit Analysis Table. From Figure 1 it can be seen that Routing Pattern #l is to be used to

handle all calls beginning with 3456 and having 8 digits.

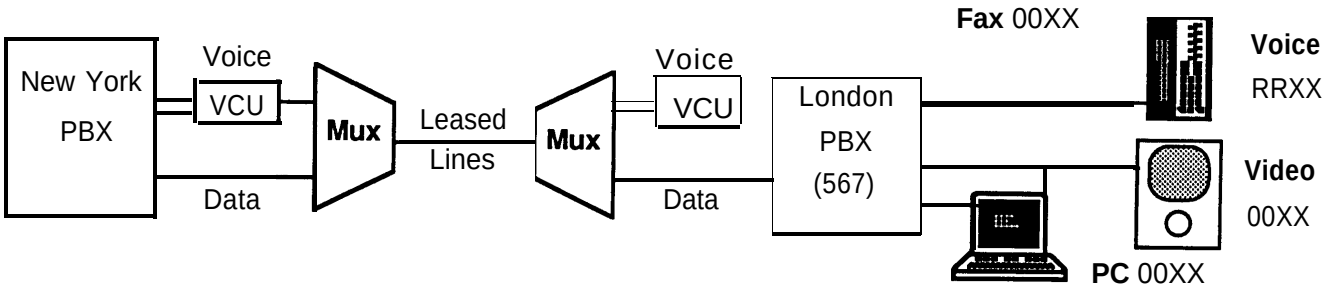
Once Routing Pattern #1 has been selected, the PBX will attempt to route the call over Trunk Group 8, the first preference. Because the digits are already in the proper form, no further digit manipulation needs to be done. If Trunk Group 8, however, can not be used, the call would be routed over international switched facilities via Trunk Group 9. In this case, the number must be converted back into a public number. To do this, the four digits of the PBX location code are deleted and the original prefix (0101212705) is re-inserted.

In another example, a call from the London office to the Tokyo office would be routed in the similar fashion except that the call would be tandemed through New York. In this case, Routing Pattern #2 will be chosen. Note that the maximum and minimum lengths are not equal because numbering plans in other countries can vary in length. A different routing pattern was used in the event that the first trunk group preference can not be used to route the call. If this happens; a different set of inserted digits must be used in order to route the call properly over the public network. Assuming that the call can be routed over Trunk Group 8 through New York and that the New York PBX was administered so that it recognizes the 6789 prefix, the New York PBX will continue routing the call to Tokyo over Trunk Group 7.

There are many other ways to administer a network like the one described here and the implementation chosen will be subject to the preferences of the network manager. This scenario was chosen in order to describe the new capabilities of M to N digit conversion and AAR/ARS digit analysis. However, with WCR, AAR and ARS have become flexible enough such that M to N digit conversion can be avoided in many cases, including this one, and the routing decisions can be performed based solely upon the AAR/ARS Digit Analysis Tables and subnet trunking. Examples of these scenarios can be found in the other applications described in these notes.

Another application of WCR in an international environment is tail end hop-off. The concept of tail end hop-off is to route public calls over a private network as much as possible before hopping off and routing the call over the public network. By doing so, companies can reduce their public network costs. Typically, this has been done in the U.S., however, with WCR this can be done internationally as well. In an international environment a company can have a gateway in a foreign country that serves as a hop-off site for the rest of the continent. For example, in this scenario a call from the London office to Mexico can be routed over the private network to the New York office in a fashion similar to that already described. The New York PBX will then complete the final leg of the call over the public network to Mexico. This can be done since WCR allows the PBX to convert a private network number back into an international public number that can be understood by the local carrier where the gateway is located. With international tail end hop-off tremendous savings can be achieved since the most expensive portion of the call, the trans-oceanic portion, will be routed over private leased facilities.

Note: Tail end hop-off is prohibited in many countries. Before implementing international tail end hop-off, consult the local carrier to determine if this practice is permissible.



AAR Digit Analysis Table - New York			
Dialed String	**Min**	**Max**	**Routing Pattern**
567	7	7	1
56700	7	7	2

Comments
Trunk Group to VCU
Trunk Group directly to Mux

VCU - Voice Compression Unit; R - Any Digit, 1-9; X - Any Digit, 0-9

Figure 2. Voice Compression and Data

Voice Compression and Data

Many companies often employ voice compression technology to carry more traffic over their leased lines, particularly international ones. Although substantial savings can be obtained, data calls, such as facsimile, that undergo voice compression are often susceptible to transmission errors.

To resolve this problem network managers have had to somehow route their data calls around the voice compression units (VCUs). To do this, separate PBX location codes can be created for data endpoints enabling AAR to differentiate voice and data calls. This, however, is an inefficient use of their private numbering plan since it is unlikely that there are 10,000 data endpoints on a PBX. Furthermore, for each PBX there must be two location codes. Another possible solution is to use outside lines separate from their PBXS to route data calls. Although both solutions solve the problem of integrating compressed voice and data, both result in a network that is not fully optimized.

Using the flexible digit analysis capabilities of WCR, network managers can route their data traffic around the VCUs and integrate their voice and data traffic over the same leased facilities without the need for separate PBX location codes or outside lines.

Figure 2 shows how this is done in a non-ISDN environment. A company with offices in London and New York are connected via private lines. Voice calls are compressed and multiplexed with data calls that have not been compressed. To route the data calls separate from the voice calls, the extensions 0000 to 0099 can be reserved for data calls while all other extensions can be used for voice. Through the AAR Digit Analysis Tables, the New York PBX can be programmed to route `56700` calls (data) separately from `567` calls (voice). With WCR if a dialed number matches two or more digit strings, the string that results in more digit matches will be the one used. Because data calls in this scenario have `00` in the fourth and fifth positions, AAR will select the first string over the second and thus the data calls are routed separately from the voice.

Another capability with WCR is the ability to use Wild Card digits in the AAR/ARS Digit Analysis Tables. Continuing on with this example, it is possible to assign all data endpoints in this private network with `00XX` extensions. Using Wild Card digits, an entry in a PBX's AAR Digit Analysis Table can be programmed to recognize `XX00XX` calls and whenever a `00` is dialed as the fourth and fifth digits, the PBX will route the call over the same non-compressed facilities.

ARS Digit Analysis Table
(PBX located in Atlantic City, NJ)

Dialed String	Min	Max	Routing Pattern	Comments
0609340	11	11	1	*Atlantic City - Intra-LATA*
0609984	11	11	2	*Trenton - Inter-LATA*
0415	11	11	2	*San Francisco - Inter-LATA*
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•

Routing Pattern 1: To LEC
Routing Pattern 2: To AT&T Operator Express

Figure 3. Operator Express

Operator Express

Operator Express Service is an AT&T service offered in the U.S. which allows call aggregators (e.g. hotels, hospitals, etc.) to route 0+ calls directly to AT&T without switching them through the Local Exchange Company (LEC). 0+ calls are used to place calling card calls, calls billed to a third number, and collect calls. All Operator Express Calls require the caller to dial 0 followed by 10 digits.

Without this service all 0+ calls (inter- and intra-LATA) are routed through the LEC Central Office (CO). lntra-LATA calls are then forwarded to the default Interexchange Carrier. With Operator Express Service all inter-LATA calls are routed directly to the AT&T CO thus allowing for faster call set up and lower access costs. lntra-LATA calls must still be handled by the LEC. To route 0+ inter-LATA calls separate from intra-LATA calls, the PBX must screen the area code and/or office code and determine which trunk group to route the call over. It should be noted that in some states AT&T is allowed to handle both inter- and intra-LATA calls. In this case all 0+ calls can be sent over Operator Express facilities.

Digit screening in states that allow Operator Express to handle both inter- and intra-LATA calls does not create any problems in PBXs with or without WCR. But in states where only inter-LATA calls can be handled by Operator Express, PBXs without WCR must use loop back trunks and partitioned routing patterns to perform the proper digit screening for 0+ calls. WCR, with its flexible digit screening capabilities, eliminates the need for these complex configurations.

Inter- and intra-LATA calls are distinguished from each other based upon the area code or the area code **and** office code. Often, the screening of the area code is sufficient to determine whether the call is an inter-LATA call. However, there are area codes that traverse two LATAs and in these situations the office codes must also be used to determine if it is an inter-LATA call.

In the above example, a caller in a hotel in Atlantic City, NJ wishes to place a credit card call to Trenton, NJ. To do so, he or she dials 9 (to access ARS) 0 followed by the remaining 10 digits. Although both locations are in the same area code (609), they are located in different LATAs. In this situation the PBX must screen the 0, office code, and area code for a total of 7 digits to determine if the call should be routed by the LEC or by AT&T. Once the call is received by the AT&T CO, the caller is prompted for his or her calling card number. Another call from the same hotel, however, to San Francisco (area code 415) only requires screening of the first 4 digits.

This example further illustrates the flexible digit analysis capabilities of WCR — the routing of a call can be performed on any combination of digits.

ARS Digit Analysis Table

Dialed String	Min	Max	Routing Pattern	*Comments*
10	16	16	1	*Route all 10+ calls to the LEC*
10111	16	16	2	*Route to lEC #1*
10222	16	16	3	*Route to IEC #2*
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•

Figure 4. Interexchange Carrier Access

Interexchange Carrier Access

Recent FCC rulings require call aggregators to allow callers access to an interexchange carrier (IXC) of their choice. Furthermore, as communications become more crucial to the success of a business, companies are employing more resilient network designs by relying on multiple IXCs to handle their long distance traffic. To satisfy these two requirements, a PBX must allow the caller to enter the Carrier Identification Code (CIC - e.g. AT&T's is 288), the code used to identify the IXC, and then route the call based upon it.

The DEFINITY Generics 2.2 and 3 provide this capability through WCR. Prior releases of the Generic 2 did not permit callers to enter the CIC and although the Generic 1.1 would accept a direct dialed CIC, it would automatically delete the CIC and route these calls to a fixed pattern, usually to the default carrier via the LEC CO. However, for operator assisted IXC calls (e.g. 10XXX0), the CIC is not deleted and can be passed to the LEC for further routing to the proper IXC operator.

With WCR, callers wishing to place a direct dialed call using an IXC other than the default can do so by dialing the ARS feature code (e.g. 9), `10XXX1,` where `XXX` is the three digit CIC, followed by the destination number. The PBX will then route the call on any set(s) of digits. For example, WCR can be used to send all calls beginning with `10` and having `16` digits to the LEC CO. The digits will be passed, unmodified, allowing the LEC to route the call to the proper IXC. Or, the PBX can have trunks to different COs (LEC and/or IXC) to access various IXCs. This maybe done to provide redundancy or for cost reasons. In any case, WCR can be used to analyze the CIC and route the call over a trunk group to the appropriate carrier.

The table in Figure 4 shows how this is done. `10111` or `10222` calls will be handled by a routing pattern that will send the call directly to the designated IXC CO. All other `10` calls will be sent to the LEC CO for further screening. `10111` and `10222` calls are not handled by Routing Pattern 1 because WCR uses the "most-matched" algorithm as described in the Voice Compression and Data Application. In this case, `10111` and `10222` calls form more matches corresponding to Routing Patterns 2 and 3, respectively. If `10333` were entered, Routing Pattern 1 would be selected.

In the call aggregator scenario, WCR provides a hassle-free way for callers to place long distance credit card calls. In addition, it allows call aggregators to block `10XXX1` calls, yet still allow `10XXX0` calls. Calls dialed with the `10XXX1` prefix will get handled by another IXC and the call aggregator will be billed for the call. The call aggregator, however, will be unable to charge the original caller for the call. But by allowing `10XXX0,` callers will be able choose an IXC and use their credit cards to charge for the call.

In the private network scenario, WCR allows callers the ability to designate an alternate IXC when the default IXC is experiencing problems. Network managers, however, may want these calls directed to only one alternate carrier. With WCR, the PBX will be able to screen the CIC and if the code is not recognized, the call will be assigned to a routing pattern that strips the dialed CIC and then inserts any necessary digits to route the call over the designated alternate carrier.

In addition to allowing callers the ability to dial CICS, WCR provides the necessary capabilities for the PBX to analyze the CIC and route the call based upon that code. More importantly, however, this example further demonstrates just how flexible call routing can be with WCR.

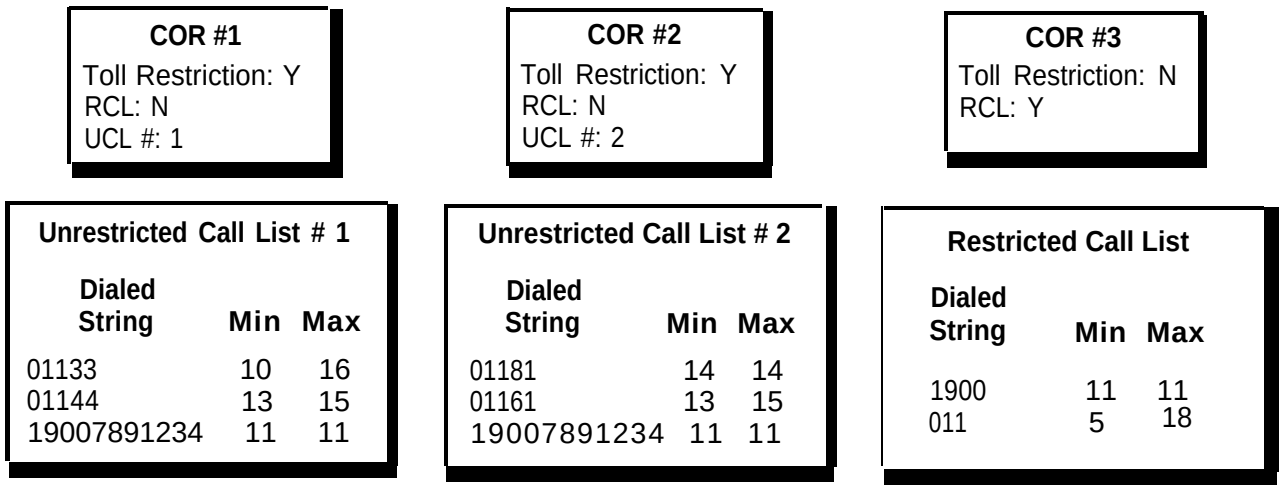


Figure 5. Selective Screening

Selective Screening

Businesses may often wish to restrict the calling privileges of employees as a means of cost control. These privileges, for example, may apply to long distance, international, or "700/900" number calls. Previous methodologies for restricting users, however, can be too restrictive and inflexible. For example, although many “900” numbers are often associated with personal entertainment services, a growing number of business related information services are provided through “900” numbers. Prior to WCR, network managers were forced to either restrict all or allow all “900” numbers — they could not selectively screen certain "900" numbers. For international calls, screening was rather limited in that it can only be done on the first three digits. With WCR, network managers have the ability to screen certain calls and vary these privileges from user to user.

Selective screening on the DEFINITY Generic 3 is accomplished through the use of Unrestricted Call Lists (UCLS) and Restricted Call Lists (RCLs). An UCL is a list of digit strings that toll restricted users can have access to. Up to 10 different UCLs can be assigned and the total number of digit strings in all 10 UCLs can not exceed 1000 — there is no limit to the number of digit strings in a particular UCL. A RCL is a list of digit strings that are to be restricted from certain users and there is only one RCL per system.

UCLs operate in the following fashion: Each extension on the PBX is assigned a Class of Restriction (COR) which can be assigned to any combination of UCLs if that COR has Toll Restriction. If a Toll Restricted user dials a toll number that is in one of the UCLs, then the call is permitted, if it is not, then the user will receive intercept treatment.

In the case of RCLS, there is a field in each COR that indicates whether the RCL applies to that COR. If it does, callers dialing from an extension identified with that COR will not be able to complete calls that are in the RCL. If it is not, then the call is allowed. Whether or not a COR is Toll Restricted does not have any revelance on the RCL. However, if the same string appears on the RCL and an UCL, the RCL has priority.

It should be noted that Authorization Codes can still be used to change the default calling privileges of an extension. Authorization Codes operate by changing the COR of an extension. When a caller enters a valid authorization code, that extension’s COR will change affecting the status of the UCLs and RCL which will lead to a different set of calling privileges.

The administration of UCLs and RCLs is very much similar to that of AAR/ARS Digit Analysis Tables: variable length dialed string patterns, wild cards, and maximum and minimum dialed string parameters are permitted. If a match between the dialed string and an entry in a UCL or RCL is found, then the call will be permitted or restricted, respectively.

An example of how Selective Screening can be used is shown in Figure 5. This scenario could be one typical of a multinational corporation with different departments responsible for markets in different parts of the world. Employees with responsibilities in France and the UK are only allowed to make international calls to those countries. Likewise for employees with responsibilities in Japan and Australia. Furthermore, employees dealing with international markets should be given access to a “900” number that provides language translation services. All other employees should be restricted from placing international and “900” number calls.

To make this happen, employees with permission to call the UK and France would be assigned to Class of Restriction (COR) #1 which is administered with Toll Restriction and UCL #1. The Toll Restriction tables are administered such that all "900" number calls are blocked. The first two entries in UCL #1 indicate that international calls to France (01133) and the UK (01144) will be the only ones permitted. The third entry gives permission to make calls to a “900” number for language translation services. Note that calls to other countries or “900” numbers are not permitted — this demonstrates the flexibility of WCR as applied to call restriction. COR #2 is assigned to employees responsible for the Australian and Japanese markets and is administered in a similar fashion as COR #1. Finally, all other employees would be assigned to COR #3 which does not have Toll Restriction, but the RCL is invoked. As a result, callers with COR #3 will not be able to make “900” or international calls.

From the applications described so far, we have seen how WCR has given network managers much greater flexibility in call routing and call restriction. Although the DEFINITY G2.2 does not provide RCL and UCL functionality, similar call restriction capabilities can be provided through the AAR and ARS Digit Analysis Tables in which each digit string can be marked with an Unauthorized Call Control FRL.

ARS Digit Analysis Table

Dialed String	Min	Max	Routing Pattern	*Comments*
115	10	10	2	*Route to SDDN*
1222	11	11	1	*New area code format - LEC*
101XXXX	18	18	1	*New IEC format- LEC*

Routing Pattern 1: To LEC
Routing Pattern 2: To AT&T's SDDN

Figure 6. Numbering Plan Expansion

Numbering Plan Expansion

The rapid expansion of telecommunications networks and services worldwide will make current public and private numbering plans obsolete in the near future. To accommodate this expansion, new numbering plans have been developed that include new formats for area codes, multi-carrier access codes, and special service codes for certain types of calls. WCR will allow networks to evolve and accommodate these changes as they happen. Some of these changes include:

- **Area Codes —** Currently, area codes in the North American Numbering Plan (NANP) are identified by having a `1` or a `0` as the second digit. But beginning in 1995 a new format for area codes will be implemented that will allow the second digit to be any number— a change that will render many of the digit analysis routines in use today obsolete. In the same fashion as in the previous applications, a DEFINITY PBX with WCR will be able to route calls based on this new format as well as any other formats in the future.
- **Expansion of International Numbering Plans —** Similar to how the NANP must change to accommodate additional users in North America, numbering plans in other countries are changing as well. In 1994 the U.K. will implement a new numbering plan in which calls dialed with a city code must be prefixed with a 1 and international calls must be prefixed with a 00. Although these changes are substantial, only administration changes will be required for DEFINITY PBXs with WCR.
- **Multi-Carrier Access Codes —** In the US, these codes are the three digit Carrier Identification Codes (CIC) that have been assigned to IXCs as a method to provide access through the LEC networks. A caller wishing to select a particular IXC dials `10` followed by the CIC. Beginning in 1993, a new format for the CIC has been proposed to expand the number of CICs available. This new format will be `101` followed by a 4 digit CIC. Likewise, callers in the U.K. can select one of two carriers to handle their calls. With WCR this new CIC format or the ability to select the carrier in the U.K. poses no problems for a DEFINITY PBX — it will be able to route calls in the same fashion as described in the Interexchange Carrier Access application.
- **ISDN** — International ISDNs in the future will implement a numbering plan that will most likely be based on international standards different from the NANP. Although these plans have not been implemented widely, WCR will be able to perform the digit analysis necessary to meet these standards.
- **Nodal Service Access** — Users of SDDN or Switched Digital International in the U.S. must dial a network feature access code (e.g. 115 and 173, respectively) to guarantee 56 Kbps digital transmission end-to-end. To dial these calls the caller typically dials the seven digit number of the destination and the PBX prefixes that number with the appropriate feature access code. However, for the PBX to recognize these calls as 56 Kbps data calls, certain office codes (RNXs) must be reserved. For the same reasons mentioned in the Voice Compression and Facsimile application, this is no longer necessary with WCR. Plus, if the call is dialed with a 115 or a 173 prefix, AAR/ARS with WCR will recognize this as a digital data call and route the call without modifying the digits.

An example of how these applications are implemented with WCR is shown in Figure 6.

System Limits For World Class Routing

	Generic 2.2	Generic 3i	Generic 3r
Maximum Dialing Lengths	31	23	23
M to N Digit Conversion			
M	31	18	18
N	31	18	18
Max Number of Conversion Entries	4096*	300	300
Subnet Trunking			
Delete	31	18	18
insert	31	36	36
Number of insert Strings	57,344	1200	3000
AAR/ARS Digit Analysis Tables			
Max Number of Entries**	5050	2000	2000
Max Number of Digits to do Routing	18	18	18
Toll Restriction			
Number of UCLs	N/A	10	10
Max Number of UCLStrings	N/A	1000	1000
Number of RCLs	N/A	1	1
Max Number of Digits to do Restriction	N/A	18	18

N/A - Not Applicable

* Shared with Subnet Trunking

** Shared between the AAR and ARS Digit Analysis Tables