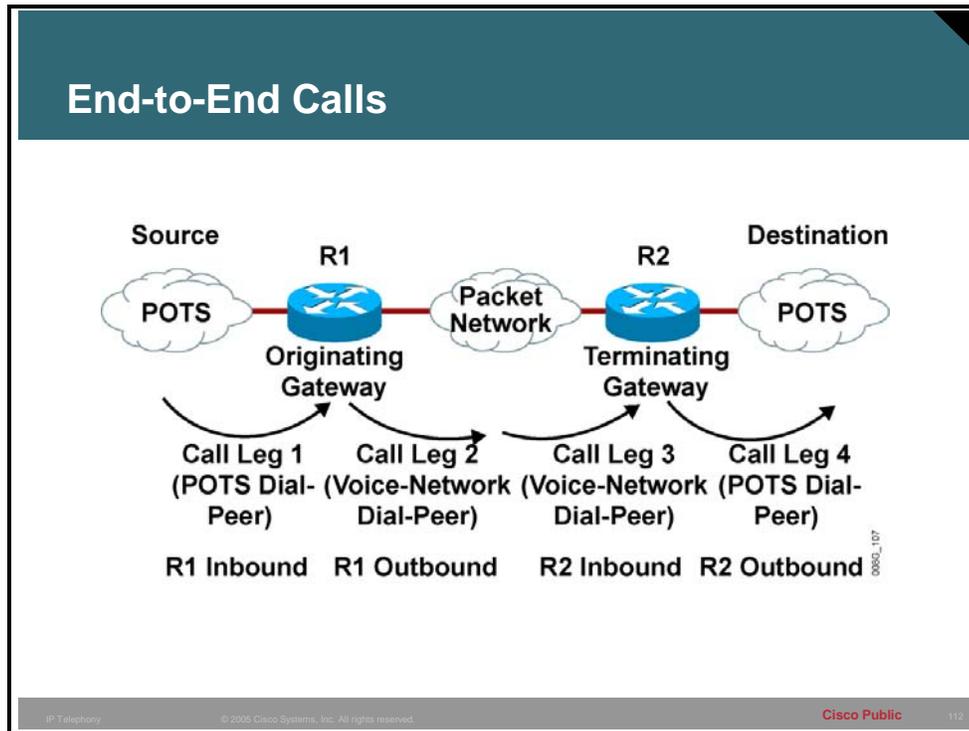# Call Setup and Digit Manipulation

End-to-End Calls

This topic explains how routers interpret call legs to establish end-to-end calls.

An end-to-end voice call consists of four call legs: two from the originating router (R1) or gateway perspective and two from the terminating router (R2) or gateway perspective. An inbound call leg originates when an incoming call comes *into* the router or gateway. An outbound call leg originates when a call is placed *from* the router or gateway.

A call is segmented into call legs and a dial peer is associated with each call leg. The process for call setup is listed below:

1. The plain old telephone service (POTS) call arrives at R1 and an inbound POTS dial peer is matched.

2. After associating the incoming call to an inbound POTS dial peer, R1 creates an inbound POTS call leg and assigns it a Call ID (Call Leg 1).

3. R1 uses the dialed string to match an outbound voice network dial peer.

4. After associating the dialed string to an outbound voice network dial peer, R1 creates an outbound voice network call leg and assigns it a Call ID (Call Leg 2).

5. The voice network call request arrives at Router 2 (R2) and an inbound voice network dial peer is matched.

6. After R2 associates the incoming call to an inbound voice network dial peer, R2 creates the inbound voice network call leg and assigns it a Call ID (Call Leg 3). At this point, both R1 and R2 negotiate voice network capabilities and applications, if required.

When the originating router or gateway requests non-default capabilities or applications, the terminating router or gateway must match an inbound voice network dial peer that is configured for such capabilities or applications.

7. R2 uses the dialed string to match an outbound POTS dial peer.

8. After associating the incoming call setup with an outbound POTS dial peer, R2 creates an outbound POTS call leg, assigns it a Call ID, and completes the call (Call Leg 4).

Matching Inbound Dial Peers

This topic describes how the router matches inbound dial peers.

Matching Inbound Dial Peers

Configurable parameters used for matching inbound dial peers:

- **incoming called-number**

  Defines the called number or dialed number identification service (DNIS) string

- **answer-address**

  Defines the originating calling number or automatic number identification (ANI) string

- **destination-pattern**

  Uses the calling number (originating or ANI string) to match the incoming call leg to an inbound dial peer

- **port**

  Attempts to match the configured dial-peer port to the voice-port associated with the incoming call (POTS dial peers only)

When determining how inbound dial peers are matched on a router, it is important to note whether the inbound call leg is matched to a POTS or VoIP dial peer. Matching occurs in the following manner:

- Inbound POTS dial peers are associated to the incoming POTS call legs of the originating router or gateway.

- Inbound VoIP dial peers are associated to the incoming VoIP call legs of the terminating router or gateway.

Three information elements sent in the call setup message are matched against four configurable dial-peer command attributes.

The three call setup information elements that are known about calls arriving at the gateway are:

Call Setup Information Elements

Call Setup Element	Description
Called number Dialed Number Identification Service (DNIS)	This is the call-destination dial string, and it is derived from the ISDN setup message or channel associated signaling (CAS) DNIS.
Calling Number Automatic Number Identification (ANI)	This is a number string that represents the origin, and it is derived from the ISDN setup message or CAS ANI. The ANI is also referred to as the Calling Line ID (CLID).
Voice Port	This represents the POTS physical voice port.

When the Cisco IOS router or gateway receives a call setup request, it makes a dial peer match for the incoming call. This is not digit-by-digit matching; instead, the router uses the full digit string received in the setup request for matching against the configured dial peers.

The router or gateway matches call setup element parameters in the following order:

How the Router or Gateway Matches Inbound Dial Peers

Step	Action
1	The router or gateway attempts to match the called number of the call setup request with the configured **incoming called-number** of each dial peer
2	If a match is not found, the router or gateway attempts to match the calling number of the call setup request with **answer-address** of each dial peer
3	If a match is not found, the router or gateway attempts to match the calling number of the call setup request to the **destination-pattern** of each dial peer
4	The voice port uses the voice port number associated with the incoming call setup request to match the inbound call leg to the configured dial peer **port** parameter
5	If multiple dial peers have the same port configured, then the router or gateway matches the first dial peer added to the configuration
6	If a match is not found in the previous steps, then the default is dial-peer 0

Because call setups always include DNIS information, it is recommended that you use the **incoming called-number** command for inbound dial-peer matching. Configuring **incoming called-number** is useful for a company that has a central call center providing support for a number of different products. Purchasers of each product get a unique 1-800 number to call for support. All support calls are routed to the same trunk group destined for the call center. When a call comes in, the computer telephony system uses the DNIS to flash the appropriate message on the computer screen of the agent to whom the call is routed. The agent will then know how to customize the greeting when answering the call.

The calling number ANI with **answer address** is useful when you want to match calls based on the originating calling number. For example, when a company has international customers who require foreign-language-speaking agents to answer the call, the call can be routed to the appropriate agent based on the country of call origin.

You must use the calling number ANI with **destination pattern** when the dial peers are set up for two-way calling. In a corporate environment, the head office and the remote sites must be connected. As long as each site has a VoIP dial peer configured to point to each site, inbound calls from the remote site will match against that dial peer.

Matching Outbound Dial Peers

This topic describes how the router matches outbound dial peers.

Outbound dial-peer matching is completed on a digit-by-digit basis. Therefore, the router or gateway checks for dial peer matches after receiving each digit, and then routes the call when a full match is made.

The router or gateway matches outbound dial peers in the following order:

How the Router or Gateway Matches Outbound Dial Peers

Step	Action
1	The router or gateway uses the dial peer **destination-pattern** command to determine how to route the call
2	The **destination-pattern** command routes the call in the following manner: ■ On POTS dial peers, the **port** command forwards the call ■ On VoIP dial peers, the **session target** command forwards the call
3	Use the **show dialplan number** *string* command to determine which dial peer is matched to a specific dialed string. This command displays all matching dial peers in the order that they are used.

Example

In the figure, dial-peer 1 matches any digit string that has not matched other dial peers more specifically. Dial-peer 2 matches any seven-digit number in the 2000 and 3000 range of numbers starting with 555. Dial-peer 3 matches any seven-digit number in the 1000 range of numbers starting with 555. Dial-peer 4 matches the specific number 5551234 only. When the

number 5551234 is dialed, dial-peers 1, 3, and 4 all match that number, but dial-peer 4 places that call because it has the most specific destination pattern.

Digit Collection and Consumption

This topic describes how the router collects and consumes digits and applies them to the dial peer statements.

Digit Consumption and Forwarding

POTS dial peers - by default the router consumes the left-justified digits that explicitly match the destination pattern and forwards wildcarded digits

POTS dial peers - use the no digit-strip command to disable the automatic digit-stripping function

VoIP dial peers - by default the router forwards all digits collected

Example 1 - dialed digits 5551234

```
dial-peer voice 1 pots
destination-pattern 555....
port 1/0:1
```

Explicitly matched digits 555 are consumed and 1234 is forwarded.

Example 2 - dialed digits 5551234

```
dial-peer voice 1 pots
destination-pattern 555....
no digit-strip
port 1/0:1
```

Digits 5551234 are forwarded.

Use the **no digit-strip** command to disable the automatic digit-stripping function. This allows the router to match digits and pass them to the telephony interface.

By default, when the terminating router matches a dial string to an outbound POTS dial peer, the router strips off the left-justified digits that explicitly match the destination pattern. The remaining digits, or *wildcard digits,* are forwarded to the telephony interface, which connects devices such as a PBX or the PSTN.

Digit stripping is the desired action in some situations. There is no need to forward digits out of a POTS dial peer if it is pointing to an FXS port that connects a telephone or fax machine. If digit stripping is turned off on this type of port, the user may hear tones after answering the call because any unconsumed and unmatched digits are passed through the voice path after the call is answered.

In other situations, where a PBX or the PSTN is connected through the POTS dial peer, digit stripping is not desired because these devices need additional digits to further direct the call. In this situation, the administrator must assess the number of digits that need to be forwarded for the remote device to correctly process the call. With a VoIP dial peer, all digits are passed across the network to the terminating voice-enabled router.

Digit Collection

The router collects digits, one at a time, until it can match an outbound dial peer.

After a match is made, the router immediately places the call.

No further digits are collected.

Example 1 - dialed string is 5551234

```
dial-peer voice 1 voip
destination-pattern 555
session target ipv4:10.18.0.1

dial-peer voice 2 voip
destination-pattern 5551234
session target ipv4:10.18.0.2
```

Dial peer 1 will match first.
Only the collected digits of 555
will be forwarded.

Example 2 - dialed string is 5551234

```
dial-peer voice 1 voip
destination-pattern 555...
session target ipv4:10.18.0.1

dial-peer voice 2 voip
destination-pattern 5551234
session target ipv4:10.18.0.2
```

Dial peer 2 will match first.
Collected digits of 5551234
will be forwarded.

When a voice call enters the network:

How the Router Collects Digits

Step	Action
1	The originating router collects dialed digits until it matches an outbound dial peer
2	The router immediately places the call and forwards the associated dial string
3	The router collects no additional dialed digits

Example

The figure demonstrates the impact that overlapping destination patterns have on the call-routing decision. In example 1, the destination pattern in dial-peer 1 is a subset of the destination pattern in dial-peer 2. Because the router matches one digit at a time against available dial peers, an exact match will always occur on dial-peer 1, and dial-peer 2 will never be matched.

In example 2, the length of the destination patterns in both dial peers is the same. Dial-peer 2 has a more specific value than dial-peer 1, so it will be matched first. If the path to IP address 10.18.0.2 is unavailable, dial-peer 1 will be used.

Matching Destination Patterns

Dialed Digits	Destination Pattern	Dialed Digits Collected
5551234	5……	5551234
5551234	555….	5551234
5551234	555	555
5551234	555T	5551234

In the first row of the table, the destination pattern specifies a seven-digit string. The first digit must be a five, and the remaining six digits can be any valid digits. All seven digits must be entered before the destination pattern is matched.

In the second row, the destination pattern specifies a seven-digit string. The first three digits must be 555, and the remaining four digits can be any valid digits. All seven digits must be entered before the destination pattern is matched.

In the third row, the destination pattern specifies a three-digit string. The dialed digits must be exactly 555. When the user begins to dial the seven-digit number, the destination pattern matches after the first three digits are entered. The router then stops collecting digits and places the call. If the call is set up quickly, the answering party at the other end may hear the remaining four digits as the user finishes dialing the string. After a call is set up, any dual-tone multifrequency (DTMF) tones are sent through the voice path and played out at the other end.

In the last row, the destination pattern specifies a variable-length digit string that is at least three digits long. The first three digits must be exactly 555, and the remaining digits can be any valid digits. The 'T' tells the router to continue collecting digits until the interdigit timer expires. The router stops collecting digits when the timer expires, or when the user presses the pound (#) key.

What Is Digit Manipulation?

This topic describes digit manipulation and the commands that are used to connect to a specified destination.

Digit Manipulation Commands

- **prefix**
  - Dial-peer command
  - Adds digits to the front of the dial string before it is forwarded to the telephony interface
- **forward-digits**
  - Dial-peer command
  - Controls the number of digits forwarded to the telephony interface
- **number expansion table**
  - Global command (num-exp)
  - Expands an extension into a full telephone number or replaces one number with another
- **digit translation**
  - Global and dial-peer command
  - Digit translation rules are used to manipulate the calling number, or ANI, or the called number, or DNIS, digits for a voice call

Digit manipulation is the task of adding or subtracting digits from the original dialed number to accommodate user-dialing habits or gateway needs. The digits can be manipulated before matching an inbound or outbound dial peer. The following is a list of digit manipulation commands and their uses:

- **prefix:** This dial-peer command adds digits to the front of the dial string before it is forwarded to the telephony interface. This occurs after the outbound dial peer is matched, but before digits get sent out of the telephony interface. Use the **prefix** command when the dialed digits leaving the router must be changed from the dialed digits that had originally matched the dial peer; for example, a call is dialed using a four-digit extension such as 1234, but the call needs to be routed to the PSTN, which requires ten digit dialing. If the four-digit extension matches the last four digits of the actual PSTN telephone number, then you can use the **prefix** command, **prefix 902555**, to prepend the six additional digits needed for the PSTN to route the call to 902-555-1234. After the POTS dial peer is matched with the destination pattern of 1234, the **prefix** command prepends the additional digits, and the string 9025551234 is sent out of the voice port to the PSTN.

- **forward-digits:** This dial-peer command specifies the number of digits that must be forwarded to the telephony interface, regardless of whether they are explicitly matched or wildcard matched. This command occurs after the outbound dial peer is matched, but before the digits are sent out of the telephony interface. When a specific number of digits are configured for forwarding, the count is right justified. For example, if the POTS dial peer has a destination pattern configured to match all extensions in the 1000 range (destination-pattern 1…), by default, only the last three digits are forwarded to the PBX that is connected to the specified voice port. If the PBX needs all four digits to route the call, you must use the command **forward-digits 4**, or **forward-digits all**, so that the appropriate number of digits are forwarded.

Note	To restore the **forward-digits** command to its default setting, use the **default forward-digits** command. Using the **no forward-digits** command specifies that no digits are to be forwarded.

- **number expansion table** (num-exp)**:** This global command expands an extension into a full telephone number or replaces one number with another. The number expansion table manipulates the called number. This command occurs before the outbound dial peer is matched; therefore, you must configure a dial peer with the expanded number in the destination pattern for the call to go through. The number expansion table is useful, for example, where the PSTN changes the dialing requirements from seven-digit dialing to ten-digit dialing. In this scenario, you can do one of the following:

  — Make all the users dial all ten digits to match the new POTS dial peer that is pointing to the PSTN

  — Allow the users to continue dialing the seven-digit number as they have before, but expand the number to include the area code before the ten-digit outbound dial peer is matched.

Note	You must use the **show num-exp** command to view the configured number-expansion table. You must use the **show dialplan number** *number* command to confirm the presence off a valid dial peer to match the newly expanded number.

- **digit translation**: Digit translation is a two-step configuration process. First, the translation rule is defined at the global level. Then, the rule is applied at the dial-peer level either as inbound or outbound translation on either the called or calling number. Translation rules manipulate the ANI or DNIS digits for a voice call. Translation rules convert a telephone number into a different number before the call is matched to an inbound dial peer, or before the outbound dial-peer forwards the call. For example, an employee may dial a five-digit extension to reach another employee of the same company at another site. If the call is routed through the PSTN to reach the other site, the originating gateway may use

translation rules to convert the five-digit extension into the ten-digit format that is recognized by the central office (CO) switch.

You can also use translation rules to change the numbering type for a call. For example, some gateways may tag a number with more than 11 digits as an international number, even when the user must dial 9 to reach an outside line. In this case, the number that is tagged as an international number needs to be translated into a national number—without the 9—before it is sent to the PSTN.

As illustrated in this topic, there are numerous ways to manipulate digits at various stages of call completion. In many cases, several of these tools will provide a workable solution. The administrator needs to determine which command will be most suitable and the requirements that are necessary for manipulation.

Note   To test configured translation rules, you must use the test **translation** command.

Example

The following is a sample configuration using the **prefix** command:

dial-peer voice 1 pots

destination-pattern 555….

prefix 555

port 1/0/0

In the sample configuration using the **prefix** command, the device attached to port 1/0/0 needs all seven digits to process the call. On a POTS dial peer, only wildcard-matched digits are forwarded by default. Use the **prefix** command to send the prefix numbers of 555 before forwarding the four wildcard-matched digits.

The following is a sample configuration using the **forward-digits** command:

dial-peer voice 1 pots

destination-pattern 555….

forward-digits 7

port 1/0/0

In the sample configuration using the forward-digits command, the device attached to port 1/0/0 needs all seven digits to process the call. On a POTS dial peer, only wildcard-matched digits are forwarded by default. The **forward-digits** command allows the user to specify the total number of digits to forward.

The following is a sample configuration using the **number expansion table** command:

num-exp 2… 5552…

dial-peer voice 1 pots

destination-pattern 5552…

port 1/1/0

In the sample configuration using the **number expansion table** command, the extension number of 2… is expanded to 5552… before an outbound dial peer is matched. For example, the user dials 2401, but the outbound dial-peer 1 is configured to match 5552401.

The following is a sample configuration using the **digit translation** command:

translation-rule 5

rule 1 2401 5552401

dial-peer voice 1 pots

translate-outgoing called-number 5

In the sample configuration using the **translation-rule** command, the rule is defined to translate 2401 into 5552401. The dial peer **translate-outgoing called-number 5** command notifies the router to use the globally defined translation rule 5 to translate the number before sending the string out the port. It is applied as an outbound translation from the POTS dial peer.

The following example shows a translation rule that converts any called number that starts with 91 and is tagged as an international number into a national number without the 9 before sending it to the PSTN.

translation-rule 20

rule 1 91 1 international national

!

!

dial-peer voice 10 pots

destination-pattern 91..........

translate-outgoing called 20

port 1/1:5

forward-digits all

PLAR

This topic describes the use of PLAR connections
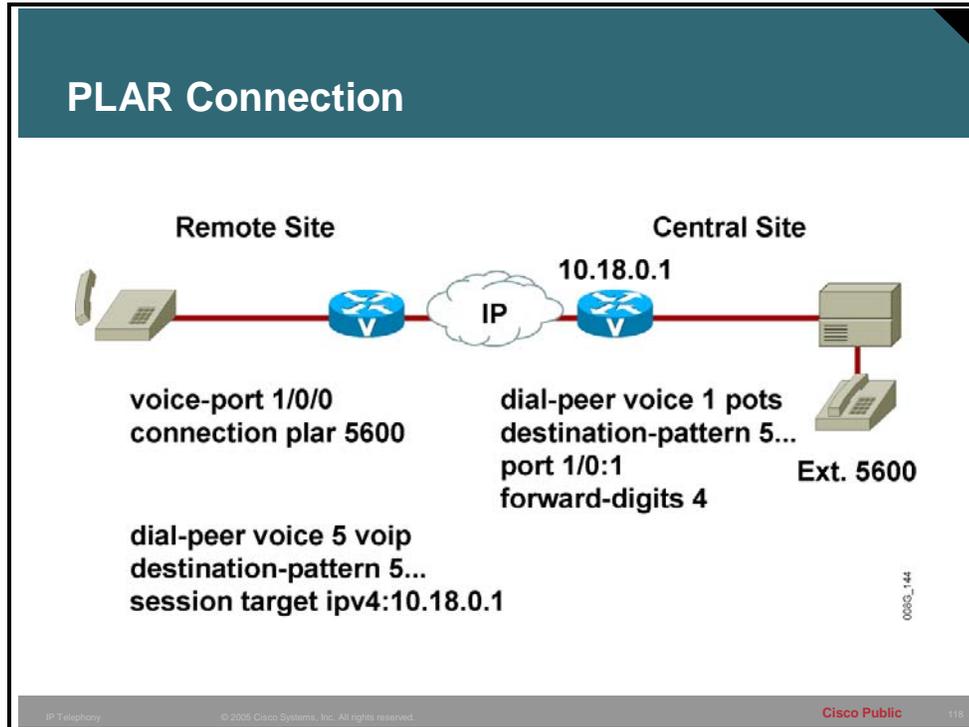
Private line, automatic ringdown (PLAR) is an autodialing mechanism that permanently associates a voice port with a far-end voice port, allowing call completion to a specific telephone number or PBX. When the calling telephone goes off hook, a predefined network dial peer is automatically matched, which sets up a call to the destination telephone or PBX. The caller does not hear a dial tone and does not have to dial a number. PLAR connections are widely used in the business world. One common use is to connect stockbrokers with trading floors. Timing is critical when dealing with stock transactions; the amount of time it may take to dial a number and get a connection can be costly in some cases. Another common use is in the travel sector, directly connecting travelers with services. Often, at places like airports, the traveler will see display boards advertising taxi companies, car rental companies and local hotels. These displays often have telephones that will connect the traveler directly with the service of choice; the device is preconfigured with the telephone number of the desired service. One obvious difference between these telephones and a normal telephone is that they do not have a dial pad.

As demonstrated in the figure, the following actions must occur to establish a PLAR connection:

1. A user at the remote site lifts the handset.

2. A voice port at the remote site router automatically generates digits 5600 for a dial-peer lookup.

3. The router at the remote site matches digits 5600 to Voice over IP (VoIP) dial peer 5 and sends the setup message with the digits 5600 to IP address 10.18.0.1 as designated in the session target statement.

4. The router at the central site matches received digits 5600 to plain old telephone service (POTS) dial peer 1 and forwards digits 5600 out voice port 1/0:1. At the same time, it sends a call-complete setup message to the router at the remote site because both the inbound and outbound call legs on the central site router were processed correctly.

5. The PBX receives digits 5600 and rings the appropriate telephone.