C H A P T E R **4**

Electronic Number Mapping and Routing

Revised: August 10, 2011, OL-24996-01

Introduction

This chapter describes electronic number mapping (ENUM) and the ENUM routing capability.

ENUM Capability

ENUM provides a simple query-based mechanism for applications to retrieve data associated with a particular E.164 address. The Cisco BTS 10200 Softswitch supports ENUM queries for on-net routing and LNP data.

Note See the *Cisco BTS 10200 Softswitch Network and Subscriber Feature Descriptions, Release 6.0.3* for a complete list of subscriber features supported by the Cisco BTS 10200.

ENUM Support for Routing

The ENUM Capability feature maps the called DN to the Uniform Resource Identifier (URI) to determine the switch on which the called DN resides. It then routes the call on-net. In order to use this feature, the service provider must deploy private or carrier ENUM servers that hold E.164-to-URI mapping for all DNs owned by the service provider.

Performing the ENUM Query

When receiving a call from a subscriber or from another network element, the Cisco BTS 10200 determines if it is the final destination of the call. If the Cisco BTS 10200 is not the final destination, it performs an ENUM query to determine the destination and obtains the URI to route the call.

The following rules apply to the Cisco BTS 10200 ENUM capability feature:

- The Cisco BTS 10200 launches the ENUM query after it receives the TCAP LNP query results, unless the same ENUM server is configured as LNP capable.
- The Cisco BTS 10200 does not perform ENUM queries for operator calls and casual calls.
- If the service provider does not want to perform ENUM lookup for an NPA-Nxx or wants to use different top-level domains for the ENUM queries based on a different NPA-Nxx, the Cisco BTS 10200 can be controlled on a configuration basis at the destination table level. a

Routing Upon Receipt of the ENUM Response

This section describes the Cisco BTS 10200 routing operation that is based on the response from the ENUM server. In general, responses from the ENUM servers fall into two categories for routing operations:

- The Cisco BTS 10200 receives a URI indicating the final destination of the E.164 number.
- The Cisco BTS 10200 does not receive any URI information.

Call Routing Based on the Received URI

If the called DN is an on-net subscriber (that is, if it is in the VoIP domain), the ENUM server returns the URI associated with the DN, indicating the address of the destination switch that can terminate the call to the subscriber. The Cisco BTS 10200 uses the domain portion of the received URI to determine the on-net path where the call should be routed.

The Cisco BTS 10200 retrieves the domain portion from the returned URI and attempts to find the on-net route configured on the Cisco BTS 10200 (in the domain2route table). For example, if the ENUM query is launched for DN1 and the ENUM response is DN2@btsX.sp.net, the Cisco BTS 10200 ignores the DN2 and uses domain btsX.sp.net to route the call. The Cisco BTS 10200 also uses the same domain in the Req-URI field of the outgoing invite message (for this example, Req-URI is set to DN1@btsX.sp.net).

Because the Cisco BTS 10200 performs a longest match for the received domain with configured routes, service providers may configure only substrings in the domain2route table to keep the number of routing entries to a minimum. For example, the user can configure the Cisco BTS 10200 to use one on-net route for bts10.region1.sp.com and another for region1.sp.com (that is, all Cisco BTS 10200 nodes in region1 except BTS10).

The Cisco BTS 10200 can also specify different policy-based routing features for each domain returned from the ENUM server. For example, Percentage Based Routing and Time of Day Routing can be applied against the domain by specifying ROUTE-TYPE=ROUTE-GUIDE.

The user can also specify multiple routes (that is, multiple softswitch trunks) against the received domain and use the Cisco BTS 10200 Route Advance feature to select an alternate on-net route in case the first on-net route cannot be used to route the call to its final destination.

The Cisco BTS 10200 can use a destination-based route (typically pointing to the PSTN interface, such as an SS7 or SIP trunk group, toward the MGC) for a particular domain received from the ENUM server. This capability can be used in various situations, such as:

- The ENUM server returns the domain of a switch for which a direct IP route does not exist.

- There are no business arrangements for routing the call on-net between two VOIP service providers.

Finally, the Cisco BTS 10200 can block the call based on the received domain. By specifying ROUTE-TYPE=NO-ROUTE in the domain2route table, this feature can be used in cases where information received from the ENUM server points to the domain of the Cisco BTS 10200 that launched the ENUM query.

Call Routing If the Cisco BTS 10200 Does Not Receive a URI or Receives a No Response message

If the called DN is not an on-net subscriber (is not in the VoIP domain), the ENUM server does not return a URI. The Cisco BTS 10200 performs the existing routing operation and chooses the route specified against the destination (for example, the SS7 route or the SIP route toward the MGC) to send the call towards the terminating switch.

The same behavior applies in the following situations when the Cisco BTS 10200 might not have a URI available to route the call on-net:

- There is no response from the ENUM server within the configured time-limit.

- No match is found for the route specified for the domain returned from the ENUM server.

- The internal Cisco BTS 10200 resources are not available to perform the ENUM query.

ENUM Routing Use Cases

Selecting Inter-CMS Trunks

Figure 4-1 shows a typical Cisco BTS 10200 configuration for deployment to a network without a SIP route proxy. The service provider can create an inter-CMS trunk group and specify the routing policy for a particular route based on the domain portion of the return URI.

Figure 4-1   Inter-CMS Trunks: Network Without SIP Route Proxy
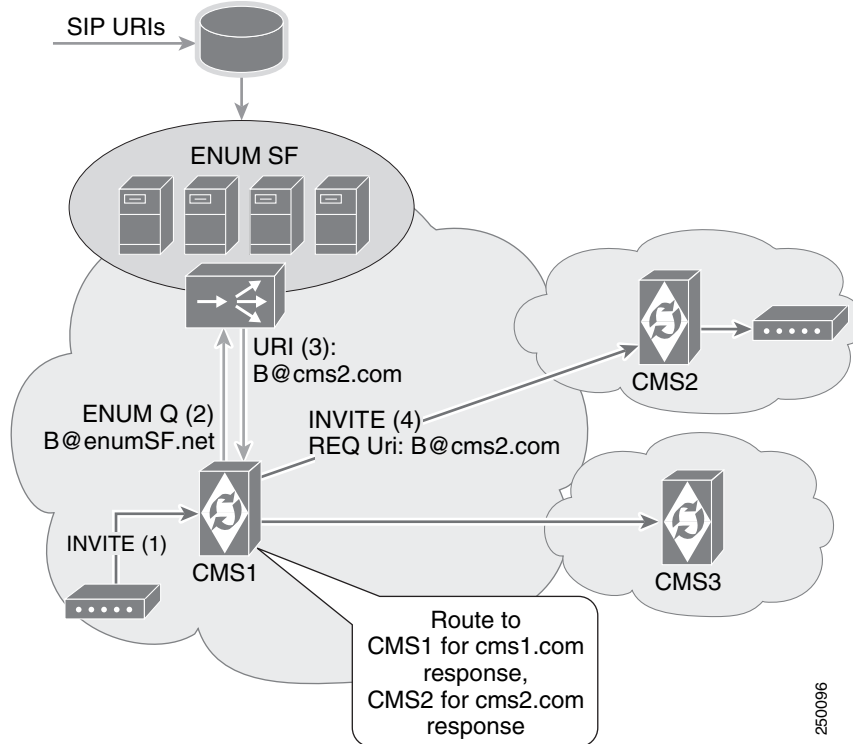
Selecting a SIP Trunk to a Route Proxy

Figure 4-2 shows a typical Cisco BTS 10200 configuration for deployment to a network with a SIP route proxy. The service provider can create one trunk group to go toward the SIP proxy and specify the routing logic for choosing the route, regardless of the domain of the returned URI. The domain portion of the returned URI is used in the Request URI for the outgoing SIP invite. The SIP proxy can direct the calls as appropriate based on this value.

*Figure 4-2*   *Inter-CMS Trunks: Network With SIP Route Proxy*
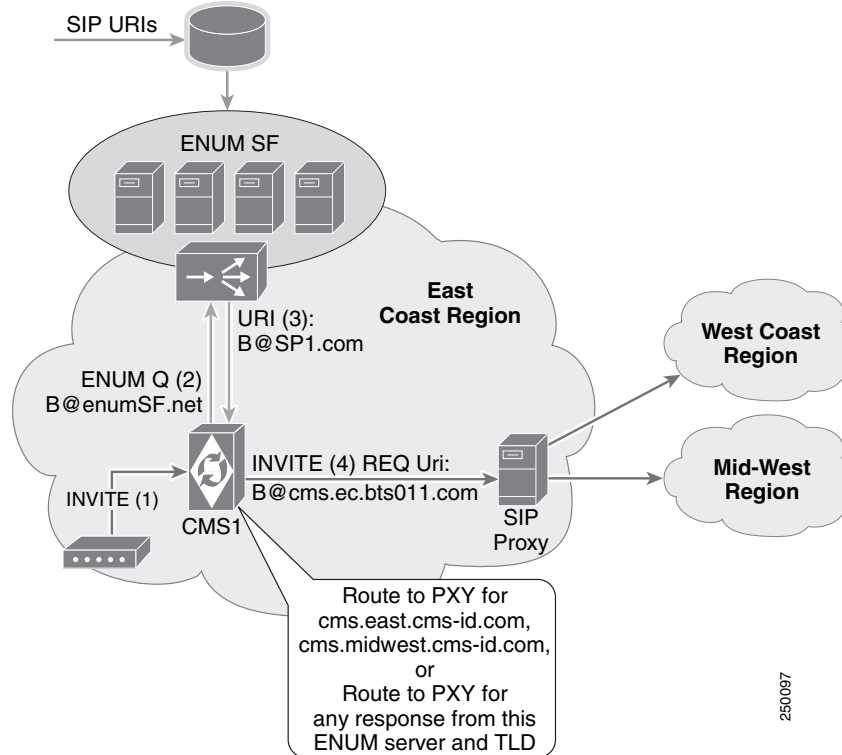
Selecting a SIP Trunk to an SBC

Figure 4-3 shows a typical configuration for routing calls for on-net subscribers in a different service provider domain when a peering arrangement to route on-net calls is established. A service provider typically uses a session border controller to route calls to or receive calls from a different service provider.

The service provider can direct one trunk group toward its own Session Border Controller (SBC) and specify the routing logic so it chooses a particular route, regardless of the domain in the returned URI. The domain portion of the returned URI is used in the Request URI for the outgoing SIP invite. The SBC can direct the calls as appropriate.

Figure 4-3   Routing a SIP Trunk to an SBC
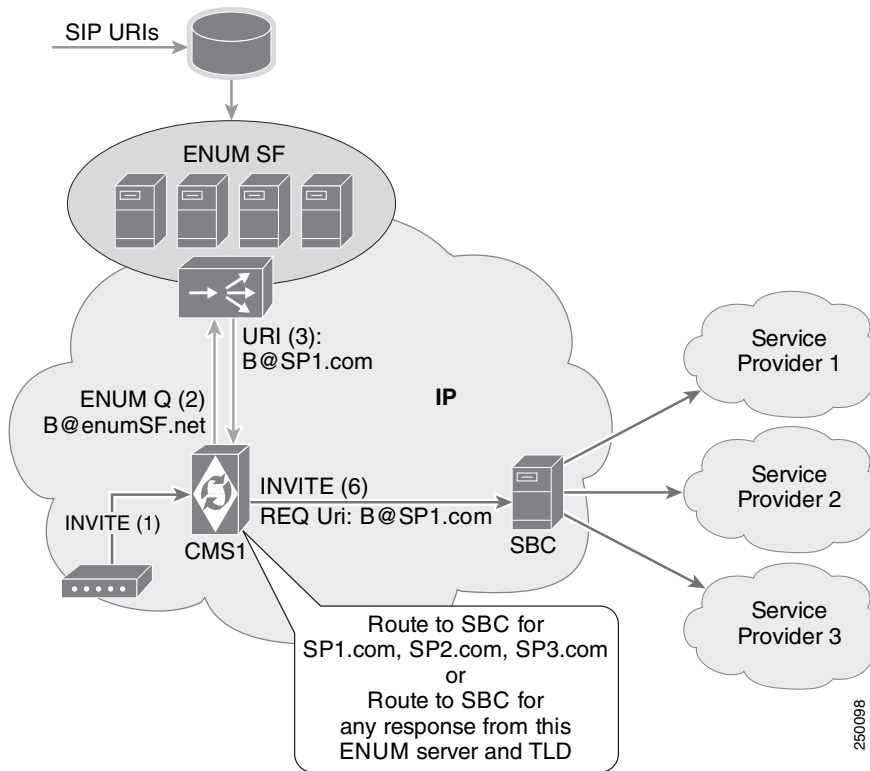
ENUM Support for LNP Data

The Call Management Server (CMS) typically retrieves LNP information by sending a TCAP query toward a Signaling Control Point (SCP) database. RFC 4769 specifies another approach in which similar information can be specified in the ENUM server (E2U+PSTN NAPTR records) and retrieved through an ENUM query rather than a TCAP query. The Cisco BTS 10200 allows the user to disable the TCAP query mechanism and retrieve LNP information using the ENUM query mechanism.

The Cisco BTS 10200 retrieves the E2U+PSTN records from the ENUM server when LNP criteria match and LNP information is required.

Note   The Cisco BTS 10200 will not use the domain portion specified against the rn field in the E2U+PSTN record for on-net routing described above.The Cisco BTS 10200 retrieves only the npdi flag (if available) and the user part of the rn field in the E2U+PSTN record.

Cisco BTS 10200 Routing Operations

The Cisco BTS 10200 uses the Local Routing Number (LRN) as well as the URI to make routing decisions. The following subsections describe the Cisco BTS 10200 routing. That behavior depends on information received by the Cisco BTS 10200 from the ENUM server.

Cisco BTS 10200 Receives the NPDI Indicator and LRN Information

The following table specifies the conditions that occur when the Cisco BTS 10200 receives the Number Portability Dip Indicator (NPDI) and LRN information:

If...	...Then
The URI is not available to the Cisco BTS 10200,	The Cisco BTS 10200 performs the routing operation based on the LRN. In addition, the Cisco BTS 102000 includes the NPDI indicator and LRN in the outgoing IAM/invite message.
The received LRN is for the same switch,	The Cisco BTS 102000 attempts to terminate the call to the subscriber.
The received LRN is a cluster LRN,	The Cisco BTS 10200 attempts to use the cluster dial plan routing to route the call.

Cisco BTS 10200 Receives Only Npdi Indicator

The Cisco BTS 10200 performs the routing operation based on the URI (if available) or the destination table. In addition, the Cisco BTS 10200 includes the NPDI indicator in the outgoing IAM/invite message to indicate that the LNP query is already performed.

Cisco BTS 10200 Receives the NPDI Indicator, LRN and URI

The Cisco BTS 10200 always attempts to select SIP routes against the domain portion of the returned URI. However, if no routing policy is specified for the returned domain or the call cannot be routed on-net due to network conditions, the Cisco BTS 10200 tries to route the call based on the LRN information it received.

The user can also configure the Cisco BTS 10200 to use the ENUM functionality to retrieve LNP data but not perform domain-based routing. To do that, the user does not specify a domain-based routing policy.

Operational Recommendations for Porting Procedures

The following sections specify how customers should configure their server when a DN is ported into a VoIP network or ported out from a VoIP network.

Porting In a DN

A DN from a different network, such as a PSTN network, is ported in to the service provider network. During the transition phase

- No update is required in the LNP database.
- No update is required in the on-net routing database.

After porting is complete, the customer should do the following:

- Specify the E2U+SIP records for the ported-in number so all the switches within the VoIP network can use the on-net routing functionality.
- Update the LNP database with the LRN or cluster LRN of the destination switch to which the subscriber is ported. This information is typically used by nodes outside the VoIP domain to route the call.

Porting Out a DN

A DN from the service provider network is ported out on a switch in a different network, such as a PSTN network. During the transition phase

- No update is required in the LNP database.
- No update is required in the on-net routing database.

After porting is complete, the customer should do the following:

- Update the LNP database with the LRN or cluster LRN from the destination switch to which the subscriber is ported out.
- Remove the E2U+SIP records in the ENUM server so all VoIP nodes can use the LRN-based routing functionality.

Porting a DN to a Different Node

If a DN is moved from Node A to Node B within the same service provider network, modifying the E2U+SIP record in the ENUM server is sufficient as long as both nodes share the same LRN or cluster LRN. If the nodes have different LRNs or cluster LRNs, we recommend updating the LNP database so calls that originate in the PSTN network are efficiently routed.

ENUM Clients Operation

This section describes the processing rules for ENUM.

Launching the ENUM query

The Cisco BTS 10200 launches the ENUM query using the E.164 number of another server. The user can specify the top-level domain and predefined digits used for the query before the Cisco BTS 10200 launches the query. Use the following steps to launch the ENUM query.

Step 1 Delete from the digit string as many leading digits as specified by DEL-DIGITS in the ENUM profile, ignoring any leading or intermediate nondigit characters. For example:

digit string=954048

DEL-DIGTS=1

Result=54048

Step 2 Prefix the digits specified by PFX-DIGITS in the ENUM profile to the transformed digit string after any leading nondigits or characters.

digit string=54048

PFX-DIGITS=1-469-25

Result=1-469-255-4048

Step 3 Remove all nondigit characters from the transformed digit string.

digit string=1-469-255-4048

Result=14692554048

Step 4 Insert dots ('**.**') between the digits of the transformed digit string.

digit string=14692554048

Result=1.4.6.9.2.5.5.4.0.4.8

Step 5 Reverse the transformed digit string.

digit string=1.4.6.9.2.5.5.4.0.4.8

Result=8.4.0.4.5.5.2.9.6.4.1

Step 6 Append the ENUM domain root specified by the TOP_LEVEL_DOMAIN of the ENUM profile to the transformed digit string.

After processing is complete, the Cisco BTS 10200 sends the query to the ENUM server specified in the profile. The Cisco BTS 10200 ENUM client provides the nonblocking querying behavior to the applications

Filtering the Response

After receiving the response from the ENUM server, the Cisco BTS 10200 extracts the URI used for on-net routing, according to the specifications in RFC 3761. The following steps describe how the Cisco BTS 10200 automatically filters the response.

Step 1 All NAPTR records in which the service field does not match the requested service are ignored.

Step 2 All nonterminal NAPTR records (those records in which the flags field is not u) are ignored.

Step 3 The remaining NAPTR records are sorted based on the order field (in decreasing order) and the preference field (in increasing order).

Step 4   All NAPTR records in which the regexp field contains malformed regular expressions are ignored.

Step 5   The NAPTR record at the top of the list sorted in Xref_Colorparanum is selected.

Step 6   The regular expression rules specified in the regexp field are applied to the digit string to obtain a URI.

Step 7   The required information is extracted from the URI. Any malformed URIs are ignored.

Step 8   One of the following occurs:

- If multiple URIs are present, the first in the list is used. Because the list has been sorted, the first in the list has priority.

- If only one URI is present, it is used for on-net routing.

- If no URIs are present, the DN is considered off-net and the call is routed using other routing rules.

Supporting Multiple Roots

The Cisco BTS 10200 can launch multiple ENUM queries toward the same set of ENUM servers or to a different set for the same call using different top-level domains. You can use this function when information for on-net subscribers is located in multiple ENUM servers, as when there is a carrier ENUM in addition to a private ENUM.

Figure 4-4 shows how the Cisco BTS 10200 supports multiple roots. In this example, it is configured to send an ENUM query to a private ENUM server farm. The private ENUM server farm responds with no record found. With the appropriate configuration, the Cisco BTS 10200 launches the query to the carrier ENUM server farm with a different top-level domain configured against the ENUM profile of carrier ENUM servers.

Figure 4-4   ENUM Queries for Multiple Roots
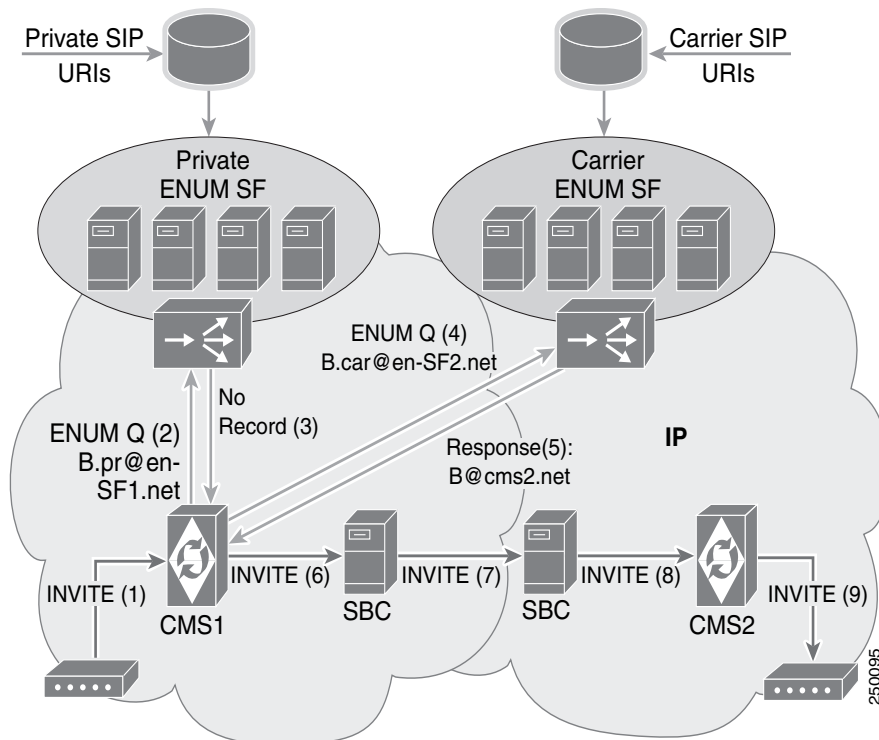
Supporting Multiple ENUM Servers

The Cisco BTS 10200 can interface with multiple ENUM servers or server farms from which it retrieves data from the SRV records. It can also distribute the ENUM queries with a round-robin or priority order policy. The following procedure describes how the Cisco BTS 10200 retrieves data from the SRV records.

Step 1   Send an SRV query to the default DNS server for the logical service name obtained from the ENUM_SERVER_DOMAIN field specified in the ENUM profile table.

Step 2   Obtain and compile a list of servers from the target field of each SRV record returned by the query.

Step 3   Send an A query to the default DNS server for each server obtained in the previous steps.

Step 4   Obtain and compile a list of ENUM server IP addresses associated with each server in the A records returned by the query.

The cached IP addresses are reached at predefined intervals specified in the ENUM_SERVER_DOMAIN_TTL field in the ENUM profile. The query retrieves all changes in network configuration or query distribution policy.

Monitoring ENUM servers and Measuring Latency

The Cisco BTS 10200 uses the actual ENUM queries and test queries to monitor the status of each ENUM server. The Cisco BTS 10200 sends a test query to an ENUM server if no actual ENUM queries are sent to that server during the period specified by the TEST-QUERY-INTERVAL parameter in the ENUM profile table. The test query used to monitor the status of an ENUM server is an NAPTR query.

The Cisco BTS 10200 uses the following logic to update the ENUM server availability status.

- If three consecutive queries (including test queries) time-out or indicate the server is unavailable, the Cisco BTS 10200 marks that ENUM server as unavailable.

- If it receives three consecutive test query responses from an ENUM server that has been marked as unavailable, the Cisco BTS 10200 marks that ENUM server as available.

The Cisco BTS 10200 calculates the round-trip delay for each ENUM and test query to determine the average latency associated with the ENUM server.

The Cisco BTS 10200 uses the latency and availability parameters to select the ENUM server to which the next ENUM query should be sent.

Prerequisites

The service provider must deploy a private or carrier ENUM server to make use of ENUM functionality on the Cisco BTS 10200. In addition, if the ENUM LNP feature is used, the same ENUM server must be configured with E2U+PSTN records for all ported DNs.