Dial Plan Design
for IP Telephony Networks

(Based on Networkers 2003 Session VVT-4010)
Q³: Quick Quiz Question

• Please try to answer for yourself the following question
• We will immediately give you the answer
• And the rest of the presentation contains the information to back up our answer!
Q³: Quick Quiz Question

• Let us consider phones A and B; both phones are registered in the same cluster; phone A is configured with extension 1000
• Phone B is configured with extension 2000
• [Q] Indicate which of the choices below is necessary and sufficient to allow phone A to be able to call phone B AND phone B to be able to call phone A
  A. Both phones are in the same partition
  B. Both phones are assigned the same calling search space
  C. Both (A) and (B)
  D. None of the above
Dial Plan—
The “IP Routing” of IP Telephony

CallManager Routes Two Basic Call Types:

**On-Cluster Calls:** Destination Directory Number (DN) is Registered with CallManager

**Off-Cluster Calls:** External **Route Patterns** Must Be Configured on CallManager
Session Scope and Objectives

- Learn how to build an enterprise IP telephony dial plan
- Design based on CallManager 3.2 or higher
- Aspects we will cover:
  - Dial plan operation
  - Design best practices
  - Caveats and recommendations
- Many US/Canada based examples were left in the preso (e.g. 911 v.s.: 080). We will highlight the differences as applicable.
Agenda

- IP Telephony Deployment Models
- Cisco CallManager Dial Plan Toolkit
- Dial Plan Design Guidelines
- Conclusions
IP Telephony Deployment Models
Single Site

- Cisco CallManager, Applications and DSP Resources at same physical location
- Supports up to 30,000 IP phones per cluster
- Multiple clusters can be interconnected via Inter-Cluster trunks
- PSTN used for all external calls
IP Telephony Deployment Models
Distributed Call Processing

- CallManager and applications located at each site
- Up to 30,000 IP phones per site
- 100+ sites
- Transparent use of PSTN if IP WAN unavailable
IP Telephony Deployment Models
Centralized Call Processing

- CallManager at central site
- Supports up to 30,000 IP phones per cluster
- Applications/DSP resources centralized or distributed
- Survivable Remote Site Telephony for remote branches
- PSTN access at each remote branch and/or central site
- Transparent use of PSTN if IP WAN unavailable (CCM 3.3)
Agenda

• IP Telephony Deployment Models

• Cisco CallManager Dial Plan Toolkit

• Dial Plan Design Guidelines

• Conclusions
CallManager Dial Plan Toolkit

- External route configuration
  - Route patterns
  - Route lists
  - Route groups
  - Route group devices
- Routing by user class or location
- Advanced tools
External Route Elements in CallManager

**Route Pattern**
- Matches dialed number for external calls
- Performs digit manipulation (optional)
- Points to a route list for routing

**Route List**
- Chooses path for call routing
- Points to prioritized route groups

**Route Group**
- Performs digit manipulation
- Points to the actual devices

**Devices**
- Gateways (H.323, MGCP)
- Gatekeeper
- Inter-cluster trunk (remote CM)

Configuration Order

1st Choice

2nd Choice
External Route Example: PHL to SJ

User Calls “526-4000”

Philadelphia

Route Pattern
“52.XXXXX”

Route List
“SJ”

Route Pattern Match
No Digit Manipulation

Select Route Group
Based on Priority

1st Choice

Route Group
“SJ-IPWAN”

2nd Choice

Route Group
“PHL-PSTN”

1. Discard Access Code “52”
Point to Remote CM via Inter-Cluster Trunk + GK

3a

3b

Prepend “1408” Point to Local PSTN Gateway

4a

4b

“64000” Sent over IP WAN to SJ CallManager

1 (408) 526-4000 Sent over PSTN to San Jose

(408) 526-4000 x64000
Route Patterns

User Calls “526-4000”

Route Pattern Match
No Digit Manipulation

Route Pattern “52.XXXXX”

Route List “SJ”

1st Choice
Route Group “SJ-IPWAN”

2nd Choice
Route Group “PHL-PSTN”

IP WAN

GK

PSTN

(408) 526-4000 x64000

Philadelphia

San Jose

User Calls “526-4000”

Route Pattern Match
No Digit Manipulation

Route Pattern “52.XXXXX”

Route List “SJ”

1st Choice
Route Group “SJ-IPWAN”

2nd Choice
Route Group “PHL-PSTN”

IP WAN

GK

PSTN

(408) 526-4000 x64000

Philadelphia
Route Patterns Configuration

Route Pattern Configuration

Route Pattern: New
Status: Ready
Note: Any update to this route pattern automatically resets the associated gateway/route list

Pattern Definition
- Route Pattern: 52.XXXXX
- Partition: IPWAN
- Description: San Jose off-net
- Numbering Plan: North American Numbering Plan
- Route Filter: < None >
- Gateway/Route List: SJ
- Route Option: Route this pattern
- Provide Outside Dial Tone: Off
- Urgent Priority: Off

Calling Party Transformations
- Use Calling Party’s External Phone Number Mask
- Calling Party Transform Mask
- Prefix Digits (Outgoing Calls)
- Calling Party Presentation
- Default

Called Party Transformations
- Discard Digits: < None >
Route Patterns
Commonly Used Wildcards

Delimiter (Does Not Match any Digits)—Used for Discarding

Range of Digits (between 2 and 9)

Single Digit between 0 and 9, * or #

One or More Occurrences of Digits between 0 and 9

The “#” Digit—Used to Avoid Inter-Digit Timeout

9 . [2-9] XXXXXXX

9.011! #

A Macro that Enters the Whole North American Numbering Plan into CallManager
(Equivalent to 166 Individual Route Patterns)

Not anymore!
Route Patterns

CallManager Call Routing Logic

User Dials “1200”

User Dials “1234”

- CallManager matches the most specific pattern (longest-match logic)
- An IP phone directory number is a special case of route pattern that matches a single number
Route Patterns
CallManager Call Routing Logic

User’s Dial String:

CallManager Actions:

Configured Route Patterns

1111
1211
1[23]XX
131
1[0-4]XX
13!
Route Patterns
CallManager Call Routing Logic

User’s Dial String:
<Off Hook>__________________

CallManager Actions:
Provide Dial Tone
Wait

Configured Route Patterns

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Might Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111</td>
<td></td>
</tr>
<tr>
<td>1211</td>
<td></td>
</tr>
<tr>
<td>1[23]XX</td>
<td></td>
</tr>
<tr>
<td>131</td>
<td></td>
</tr>
<tr>
<td>1[0-4]XX</td>
<td></td>
</tr>
<tr>
<td>13!</td>
<td></td>
</tr>
</tbody>
</table>

Digit analysis: potentialMatches=PotentialMatchesExist
Route Patterns
CallManager Call Routing Logic

User’s Dial String:
1

CallManager Actions:
Break Dial Tone
Wait

Configured Route Patterns

<table>
<thead>
<tr>
<th>Route Pattern</th>
<th>Might Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111</td>
<td></td>
</tr>
<tr>
<td>1211</td>
<td></td>
</tr>
<tr>
<td>1[23]XX</td>
<td></td>
</tr>
<tr>
<td>131</td>
<td></td>
</tr>
<tr>
<td>1[0-4]XX</td>
<td></td>
</tr>
<tr>
<td>13!</td>
<td></td>
</tr>
</tbody>
</table>

Digit analysis: match(fqcn="9195555644", cn="15644", pss="PA:Line1:Cisco:Local:Long Distance:International", dd="1")
Digit analysis: potentialMatches=POTENTIALMATCHESEXIST
Route Patterns
CallManager Call Routing Logic

User’s Dial String:

13

CallManager Actions:
Wait

Configured Route Patterns

<table>
<thead>
<tr>
<th>Digit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111</td>
<td>Doesn’t Match</td>
</tr>
<tr>
<td>1211</td>
<td>Doesn’t Match</td>
</tr>
<tr>
<td>1[23]XX</td>
<td>Might Match</td>
</tr>
<tr>
<td>131</td>
<td>Might Match</td>
</tr>
<tr>
<td>1[0-4]XX</td>
<td>Might Match</td>
</tr>
<tr>
<td>13!</td>
<td>Might Match</td>
</tr>
</tbody>
</table>

Digit analysis: potentialMatches=PotentialMatchesExist
**Route Patterns**

**CallManager Call Routing Logic**

User’s Dial String:

131

CallManager Actions:

Keep Waiting; More Digits Might Cause a Different Pattern to Match

![Configured Route Patterns](image)

<table>
<thead>
<tr>
<th>User's Dial String</th>
<th>Configured Route Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>131</td>
<td>Doesn't Match</td>
</tr>
<tr>
<td>1211</td>
<td>Doesn't Match</td>
</tr>
<tr>
<td>1[23]XX</td>
<td>Might Match</td>
</tr>
<tr>
<td>131</td>
<td>Match!</td>
</tr>
<tr>
<td>1[0-4]XX</td>
<td>Might Match</td>
</tr>
<tr>
<td>13!</td>
<td>Match! and Might Match</td>
</tr>
</tbody>
</table>


Digit analysis: potentialMatches=PotentialMatchesExist
Route Patterns
CallManager Call Routing Logic

User’s Dial String:
1311

CallManager Actions:
Keep Waiting; More Digits Might Cause a Different Pattern to Match

Configured Route Patterns

<table>
<thead>
<tr>
<th>Route Pattern</th>
<th>Match Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111</td>
<td>Doesn’t Match</td>
</tr>
<tr>
<td>1211</td>
<td>Doesn’t Match</td>
</tr>
<tr>
<td>1[23]XX</td>
<td>Match!</td>
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<td>Match!</td>
</tr>
<tr>
<td>13!</td>
<td>Match! and Might Match</td>
</tr>
</tbody>
</table>

Digit analysis: match(fqcn="9195555644", cn="15644", pss="PA:Line1:Cisco:Local:Long Distance:International", dd="1311")
Digit analysis: potentialMatches=PotentialMatchesExist
Route Patterns
CallManager Call Routing Logic

User’s Dial String:
1311<timeout>

CallManager Actions:
Extend Call to the **Best** Match

<table>
<thead>
<tr>
<th>Configured Route Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111</td>
</tr>
<tr>
<td>1211</td>
</tr>
<tr>
<td>1[23]XX</td>
</tr>
<tr>
<td>1[0-4]XX</td>
</tr>
<tr>
<td>13!</td>
</tr>
</tbody>
</table>

- **1111** Doesn’t Match
- **1211** Doesn’t Match
- **1[23]XX** Match!
- **1[0-4]XX** Match!
- **13!** Match!

Can You Tell which Route Pattern Is the Best Match in This Case?  
**Hint:** We Are Being Crafty to Make Sure You Remember Forever 😊
Route Patterns
CallManager Call Routing Logic

User’s Dial String:

1311<Timeout>

Matches 200 Digit Strings

Matches 500 Digit Strings

Matches ∞ Digit Strings, However for the Purposes of Closest Match Routing in this Case, this Matches 100 Digit Strings because You Only Consider the Number of Potential Strings Given the Number of Digits Dialed

Configured Route Patterns

|-----------------------------------|-------------------|-------------------|----------------|----------------|----------------|--------|

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Route Lists

Philadelphia

User Calls “526-4000”

Route Pattern “52.XXXXX”

Route List “SJ”

Select Route Group Based on Priority

1st Choice
Route Group “SJ-IPWAN”

2nd Choice
Route Group “PHL-PSTN”

Route Pattern “SJ-IPWAN”

GK

San Jose

PSTN

IP WAN

(408) 526-4000 x64000
Route Lists Configuration

- Prioritized list of Route Groups
- Route Groups used to reach destination via different paths
- Digit manipulation in Route Group based on "parent" Route List
Route Groups

User Calls “526-4000”

Route Pattern “52.XXXX”

Route List “SJ”

Route Group “PHL-PSTN”

Prepend “1408” Point to Local PSTN Gateway

1st Choice

Route Group “SJ-IPWAN”

2nd Choice

Route Group “SJ”

1st Choice

Route Pattern “52.XXXX”

Route List “SJ”

User Calls “526-4000”

(408) 526-4000 x64000

San Jose

PSTN

IP WAN

GK
Route Groups
Viewed from within the Route List

Note:
- Digit manipulations in Route Group cancel and override those defined in Route Pattern
- Digit manipulation recommended in Route Group

Digit Manipulation
Prepend “1408”
Route Groups
Digit Manipulation Notes

- Order used to apply digit manipulations:
  1. Discard digits instructions
  2. Called party transformation mask
  3. Prefix digits

- If Checked, Uses CLID Configured on IP Phone
- Transforms Calling Line ID (CLID)
- Transforms Called Number
Route Groups

d Standalone View

Route Group Configuration

Route Group Name: SJ IPWAN
Status: Ready

Actual Device(s) Pointed by the Route Group

* indicates required item
Route Group Devices

User Calls “526-4000”

Route Pattern “52.XXXXX”

Route List “SJ”

1st Choice

Route Group “SJ-IPWAN”

2nd Choice

Route Group “PHL-PSTN”

4a

“64000” Sent over IP WAN to SJ CallManager

4b

1 (408) 526-4000
Sent over PSTN to San Jose

(408) 526-4000
x64000

Philadelphia

San Jose

PSTN

IP WAN

GK
Route Group Devices
Device Types

Route Group

MGCP Gateways
- VG-200
- Cat 6K T1/E1
- 26xx-36xx
- IAD 2400

Dial Plan Config. in CallManager

H.323 Gateways (H.225)
- All Cisco IOS gateways

Device Protocol = H.225
Dial Plan in Cisco IOS

H.323 Gateways (Inter-Cluster Trunk)
- Other CallMgr clusters

Device Protocol = Inter-Cluster Trunk

Anonymous Device/H.323 Trunk (in 3.3)
- Cisco IOS Gatekeeper

Delegates External IP WAN Routing to the Gatekeeper
### Route Group Devices
### H.323 Gateway Configuration (CallManager)

#### Gateway Configuration

<table>
<thead>
<tr>
<th>Device Name*</th>
<th>10.1.20.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>Device Pool*</td>
<td>Default</td>
</tr>
<tr>
<td>Calling Search Space</td>
<td>Incoming_PHL_GW</td>
</tr>
<tr>
<td>Location</td>
<td>&lt; None &gt;</td>
</tr>
<tr>
<td>Caller ID DN</td>
<td></td>
</tr>
<tr>
<td>Calling Party Selection*</td>
<td>Originator</td>
</tr>
<tr>
<td>Presentation Bit*</td>
<td>Allowed</td>
</tr>
<tr>
<td>Display IE Delivery</td>
<td></td>
</tr>
<tr>
<td>Gatekeeper Name</td>
<td>&lt; None &gt;</td>
</tr>
<tr>
<td>Media Termination Point</td>
<td></td>
</tr>
<tr>
<td>Num Digits*</td>
<td>23</td>
</tr>
<tr>
<td>Sig Digits</td>
<td></td>
</tr>
<tr>
<td>Prefix DN</td>
<td>3</td>
</tr>
</tbody>
</table>

- **Device Name**
  - IP Address of H.323 GW
- **Calling Search Space**
  - Defines Where this Device May Place Inbound Calls
- **Is Gatekeeper Needed to Call this Device?**
- **To Strip All But Significant Digits for Incoming Calls**
- **To Prefix Incoming Calls**

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Route Group Devices
H.323 Gateway Configuration (Cisco IOS)

dial-peer voice 101 voip
destination-pattern .......... session target ipv4:10.1.20.25
dtmf-relay h245-alphanumeric codec g711ulaw
ip qos dscp af31 signaling
ip qos dscp ef media
!
dial-peer voice 1 pots
destination-pattern 1.......... port 3/1/1 (Long Distance)
prefix 1
!
dial-peer voice 2 pots
destination-pattern 911 port 3/1/1 (Emergency)
prefix 911
!
dial-peer voice 5 pots
destination-pattern ........ port 3/1/1 (Local 7 Digit Dialing)
!
dial-peer voice 6 pots
destination-pattern 011T port 3/1/1
prefix 011 (International Dialing)
The “Anonymous Device” is introduced to use the Gatekeeper for Dial Plan Resolution (as well as Call Admission Control). It is introduced to use the Gatekeeper for Dial Plan Resolution (as well as Call Admission Control).

Allow Anonymous Calls
Create “Anonymous Device”

Device Protocol
In CallManager 3.2, this is the DEFAULT Device Protocol.
Route Group Devices
Anonymous Device—Auto-Discovery

- During H.225 setup, CallManager identifies itself to the remote device
- If the remote device identifies itself as another CallManager, supplementary services can be used
- Otherwise, the default Device Protocol is used

Use H.225 as Default Device Protocol if all CallManagers Are 3.2 or Later
Route Group Devices
H.323 Trunks (3.3)—New Simplicity and Possibilities

ICT Simplicity!
Inter-Cluster Trunk

San Jose
HQ
Publisher

New York

RRQ CM1 (CM2 and CM3)
ACF CM1 (CM2 and CM3)

Alternative Endpoint Support!

GKA
GKB
GKC

H.323 Network (e.g.: intl)

RRQ (to GKA)

Alternate Gatekeeper Support!
Inter-Cluster Trunks—Redundancy

As of CallManager 3.3, Redundancy Is Built into the Inter-Cluster Trunk (2 ICTs instead of 6)

Remote Cisco CallManager Information

<table>
<thead>
<tr>
<th>Server Type</th>
<th>IP Address/Host Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server 1</td>
<td>172.16.1.100</td>
</tr>
<tr>
<td>Server 2</td>
<td>172.16.2.100</td>
</tr>
<tr>
<td>Server 3</td>
<td>172.16.3.100</td>
</tr>
</tbody>
</table>

* indicates required item

Back to Find/List Trunk
Configuration—Inter-Cluster Trunk

- Calls to an inter-cluster trunk without GK-control are load shared in a round robin fashion among the configured peer signaling addresses.

- For example, the first call is routed to peer transport address 1, next call to peer transport address 2, 3rd call to transport address 3, 4th call to transport address 1, and so forth.
Alternate Endpoint Support

No Extra Config Needed Here; the CallManager Will Advertise All Servers in the CallManager Group of the Trunk (as Associated to the Device Pool) in the RRQ
Alternate GK Support

Up to 10 Gatekeepers Can Be Defined in CallManager 3.3

Alternate GK Support
No Extra Config Needed Here; the Alternate GK Addresses Will Be Returned in the RCF from this GK
H.323 Trunk Possibilities

- Up to 10 Gatekeepers can be defined
- Trunks allow multiple path into IP telephony networks: IP IXC, IP LEC, theaters, etc...
- When a GK-controlled trunk is configured with more than one CCM in the device pool, CCM will automatically send RRQ with alternate endpoints when backup CCM(s) come up in service
- If the given destination call signaling address is unreachable, all of the alternate CCMs in the device pool will be attempted before giving up
- No CLI configuration in Cisco IOS GK is needed
- Alternate endpoint is supported in IOS GK load 12.2T
H.323 Enhancements
CanMapAlias

- Time of day routing (follow the sun)
- Follow me service (virtual phone number)
- “Number mobility” single point of administration
- Hotel “gold customer” 1-800-WhateverHotelRoomThisWeek
CallManager Dial Plan Tool Kit

• External route configuration
• Routing by user class or location
  Partitions
  Calling search spaces
• Advanced tools
Routing by User Class or Location

Create “Classes of Service” to Define Calling Restrictions

Instruct Remote Phones to Use Their Local Gateway for PSTN Access
Partitions and Calling Search Spaces
Analogy with Subnets/Access Lists

- **Partition**—“where you are”
  Collects devices with similar “reachability” characteristics
  Items placed in partitions:
  Directory Numbers (DN), route patterns, voice mail ports...

- **Calling Search Space**—“where you may call”
  Set of rules to set call restrictions/permissions
  Defines which partitions a device may search to reach a dialed number
  Is assigned to IP phones, GWs
Partitions and Calling Search Spaces

- Partitions and Calling Search Spaces cause the majority of call routing configuration errors
- Understanding Partitions and Calling Search Spaces is essential to understanding call routing in CallManager
- Allow toll bypass from one geographical region to another
- Allow different outside calling privileges by class of calling user
- Allow multiple tenants with overlapping dial plans to be served by the same CallManager
Partitions and Calling Search Spaces Analogy

Rita Wants to Call Dave
To Do So, She Needs to Know Dave’s Number

Miami Yellow Pages
Dave 305 555 5000

Dave Lists His Number in a Directory

Dave 305 555 5000

Rita Wants to Call Dave
Partitions and Calling Search Spaces Analogy

To Look up Numbers, Rita Looks through the Directories She Owns

If She Doesn’t Have the Right Directory…

Rita’s List of Directories
- Dallas White Pages
- Outlook Address Book
- Little Black Book

…She Can’t Place the Call

Miami Yellow Pages
Dave 305 555 5000

Rita

Dave
305 555 5000
Partitions and Calling Search Spaces
Analogy

But if She Has the Directory Dave Has Listed His Number in...

Rita’s List of Directories
- Dallas White Pages
- Miami Yellow Pages
- Little Black Book

Miami Yellow Pages
Dave 305 555 5000

...the Call Will Go Through

Rita

Dave
305 555 5000
Partitions and Calling Search Spaces

Analogy

The Directory in which Dave’s Number Is Listed Is His Number’s Partition

Miami Yellow Pages
Dave 305 555 5000

Rita’s List of Directories
Dallas White Pages
Miami Yellow Pages
Little Black Book

The List of Directories in which Rita Looks up Numbers Is Her Calling Search Space

Dave
305 555 5000
Partitions and Calling Search Spaces
Definition

- **Partition**: A logical grouping of patterns; all patterns in a partition are equally reachable

- **Calling search space**: An *ordered* list of partitions; digit analysis looks through the caller’s list of partitions when searching for the closest match for the caller’s dialed number
Partitions and Calling Search Space Rules

- Calling entities (phones, lines, gateways, applications) have calling search spaces
- Called entities (route patterns, translation patterns, directory numbers, feature codes) have partitions
Partitions and Calling Search Space Rules

• Digit analysis looks through every partition in a calling search space and looks for the best match

• The order of the partitions listed in the calling search space is used only to break ties when there are equally good matches in two different partitions

• Contrary to popular belief, the partition the calling party’s line is in has NO effect on where you can call from that line; only the Calling Search Space for that phone/device matters
Partitions and Calling Search Space Rules

- If no partition is specified for a pattern, the pattern is listed in the null partition.
- All callers look in the null partition (as well as any partitions specified in their calling search space) to resolve dialed digits.
- The null partition is always the last partition in any Calling Search Space.
- Closest-match routing takes precedence over the partition ordering in a Calling Search Space, so a closer match in the null partition will be used to route a call over a less-explicit match in a partition.
Partitions and Calling Search Spaces Configuration

**List of Partitions that Can Be “Seen” by this Calling Search Space**

**NOTE:**
- CallManager Stores a CSS as colon-separated list of partitions
- Maximum length of CSS Is 512 bytes
Partitions and Calling Search Spaces
Impact of Partition Order

- Most specific patterns are chosen irrespective of partition order
- Partition order is only used as a tie-breaker in case of equal matches
Partitions and Calling Search Spaces
How to Build Classes of Service

Calling Search Spaces
- InternalOnly
- LocalOnly
- Unrestricted

Partitions
- Internal
- Local
- Long Distance

Default CSS
- <None>

Calling Search Space Assigned to IP Phone Based on Policy

All IP Phones, Voice Mail, Media Resources, 911 Route Pattern
- Local Route Patterns
- Long Distance Route Patterns

Default Partition
Partitions and Calling Search Spaces Determine Class of Service AND Call Path (1/2)

- **Calling Search Spaces**
  - Internal Only
  - Local
  - National
  - International

- **Partitions**
  - Internal
    - All IP Phones
    - 911
    - 9.911
  - Local
    - 9.[2-9]XXXXXX
  - National
  - International
    - 9.011!
    - 9.011!#

- **Route Lists**
  - PSTN RL

- **Route Groups**
  - PSTN RG

- **Devices**
  - SF Gateway
  - PSTN

- **Calling Search Spaces Partitions**
- **Route Lists**
- **Route Groups**
- **Devices**

- **Route Patterns**

- **Calling Search Space Assigned to IP Phone Based on Policy**

- **International Only**
- **Local**
- **National**
- **International**

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Partitions and Calling Search Spaces
Determine Class of Service AND Call Path (2/2)

Calling Search Spaces

NY911
- 911
- 9.911

NYLocal
- 9.[2-9]XXXXXX

NYNational
- 9.1 [2-9]XX
- [2-9]XX XXXX
- All Phones contains all phones for the entire enterprise

SF911
- 911
- 9.911

SFLocal
- 9.[2-9]XXXXXX

SFNational
- 9.1 [2-9]XX
- [2-9]XX XXXX

Route Pattern

Route Lists
- 911_NY NL
- PSTN_NY NL
- CAMA_NY NL

Route Groups
- 2nd
- 1st

NY_Local

NTL_NY
- New York

NTL_SF
- San Francisco

Devices

Cameras
- CAMA
- 911 LEC

PSTN

NY Gateways

SF Gateway

Calling Search Spaces

Partitions

Route Pattern

Route Lists

Route Groups

All_Phones contains all phones for the entire enterprise
Partitions and Calling Search Spaces

• Previous slides have important implications:
  The Calling Search Space implements a “class of service” (e.g.: Local, National, etc…).
  AND
  It ultimately chooses the path of the call, including the Gateway

• For these reasons, if you have N branches, and X classes of service, you need (N times X) Calling Search Spaces

• An alternative approach is possible!
Partitions and Calling Search Spaces
Device-Line CSS Interaction

The CSS of the Device Has an Effect on All Calls Made from that Phone.
Partitions and Calling Search Spaces
An Alternative Approach

Device’s CSS. “All Permitting”, and Locally Significant

CSS_NY_D

The Effective CSS for a Call Is the Concatenation of the Line’s CSS Followed by the Device’s CSS

NY911
911
9.911

NYLocal
9.[2-9]XXXXX

NYNational
9.1 XXX
[2-9]XX XXX

All_Phones Contains All Phones for the Entire Enterprise

No_National
9.1 [2-9]XX
[2-9]XX XXXX
(blocked)

Line’s CSS; List of Blocked Patterns, Globally Significant

CSS_lcl_Only

Route Pattern

Route Lists

Route Groups

Devices

CSS_NY_D

911_NY RL

2nd

CAMA_NY
RG

1st

LEC

PSTN

NY
Gateways

Bogus

Bogus

Bogus

911

911

911

911

911

911

911

911
Partitions and Calling Search Spaces
An Alternative Approach (Summary)

• Create an unrestricted calling search space for each location and assign it to the phone’s device calling search space; this calling search space should contain partitions featuring route patterns that route the calls to the appropriate gateway for the phone’s location (e.g.: a co-located branch GW for emergency services and local calls, etc…)

• Create calling search spaces containing partitions featuring blocked route patterns for those types of calls not part of the user’s dialing privileges, and assign them to the user's lines; for instance, if a user has access to all types of calls except international, his line (or lines) should be configured with a calling search space featuring a blocked route pattern for international dialing. Be as specific as possible!!! Make sure that the blocked pattern is a better match.
Partitions and Calling Search Spaces
An Alternative Approach (Summary)

- This approach allows the enterprise with N locations and X classes of service to implement N + X Calling Search Spaces, as opposed to N times X.
- This approach also allows Extension Mobility to work in a centralized call processing environment.
- Call Forward functionality only uses a single CSS (no concatenation with the device’s CSS): if you have specific CFNA, CFB or CFA needs, you may need to create more CSSes.
CallManager Dial Plan Tool Kit

- External route configuration
- Routing by user class or location
- Advanced tools
  - Translation patterns
  - Route filters
  - Automated alternate routing
Translation Patterns
The Basics

• Looks like a Route Pattern, allows digit manipulation
• Instead of sending calls outside via a route list, forces second lookup in CallManager, using a (possibly different) Calling Search Space

Translation Pattern
Transforms “0” in 2001 and Forces Second Lookup

Dials “0” to Reach Operator

Delivers “2001”
Translation Patterns Configuration

Translation Pattern Configuration

Translation Pattern: 1XXX
Status: Update completed

Pattern Definition
Translation Pattern: 1XXX
Partition: gearanto-isdn users
Numbering Plan*: North American Numbering Plan
Route Filter: < None >
Calling Search Space: Unrestricted
Route Option: 
- Route this pattern
- Block this pattern
- Provide Outside Dial Tone
- Urgent Priority

Calling Party Transformations
- Use Calling Party's External Phone Number Mask
Calling Party Transform Mask:

Called Party Transformations
Discard Digits: AccessCode
Called Party Transform Mask: 4XXX
Prefix Digits (Outgoing Calls):

Note:
Translation Patterns Are Routed as Urgent; as Soon as It Is the Best Match, it Routes the Call Even if There Are Other Potential Matches
Translation Patterns
Example—Overlapping Extensions

Inter-Site Access Code = "8"

Calling Search Spaces

Partitions

Delivers 1XXX

Site1_Internal
Site 1 IP Phones

Site1_Internal

Site2_Internal
Site 2 IP Phones

Site2_Internal

On_Cluster

81.1XXX [Discard PreDot]
82.1XXX [Discard PreDot]
83.2XXX [Discard PreDot]

Translation Patterns Force a Second Lookup Using a Different Calling Search Space

To Site3_Internal
Route Filters
The Basics—“9.@” Route Pattern

- The “@” wildcard represents all the routes defined in the national numbering plan.
- CallManager identifies tags in each number:
  INTERNATIONAL-ACCESS
  AREA-CODE
  OFFICE-NUMBER...
- Route filters are logical expressions that operate on these tags.
- Useful for blocking 900, Caribbean, international...

North American Numbering Plan:
9.[2-9]11
9.[2-9]XX XXXX
9.011!

“INTERNATIONAL-ACCESS” DOES-NOT-EXIST
AND
“AREA-CODE” DOES-NOT-EXIST

Actual Routes in CallManager:
9.[2-9]11
9.[2-9]XX XXXX
Route Filter Configuration

Choose a Dial Plan*: North American Numbering Plan

Route Filter Name: Domestic calls
Clause: (AREA-CODE EXISTS AND INTERNATIONAL-ACCESS DOES-NOT-EXIST)
AAR—Automated Alternate Routing

• Allows for calls to DNs to be re-routed through an alternate network (e.g.: PSTN) if there is insufficient bandwidth to reach the destination

• Introduced in CCM 3.3

• Need to set “Automated Alternate Routing Enable” to True (default is False)
AAR—Summary

AAR Will Re-Route the Call through the PSTN!

No BW Available
Call Denied by CAC
AAR—Required Information

- 51234 dials 55678, and call is denied by CAC
- System needs to know how to reach 55678 through the PSTN

What is the PSTN-dialable number for extension 55678?

 Called phone’s External Phone Number Mask: 212 555 5678!

How do I reach this number from San Francisco?

 Need to pre-pend 9 1; 9 1 212 555 5678!

What Gateway do I use from San Francisco to dial this number?

 San Francisco’s local GW!
AAR—Configuration

- AAR calls are assigned their own independent Calling Search Space; gateway selection can thus be segregated to AAR calls (i.e.: central site GW for long distance normally, but local for AAR LD calls)

- DNs placed in AAR groups

- All AAR groups form a matrix, used to determine what prefixes are required to reach destination
AAR Group—Any to Any Prefix Rules

- Full prefix matrix between AAR groups
- Can have more than one branch within a region
  - e.g.: two branches in San Francisco
- Use “9” only between two San Francisco branches in the same AAR group
AAR Group Assigned to DN!

- DNs are assigned to an AAR group
- But, the CSS used for AAR calls is on the device (see next slide)
AAR Calling Search Space Assigned to *Device*

- Be mindful of this for Extension Mobility
- This is how an AAR-specific gateway can be chosen
- You could also, since this is a CSS, have a route list that matches the dialed number
- This would let you choose any combination of WAN or PSTN paths
AAR Rules and Caveats

- **Rule 1:** The originating IP phone and the outgoing gateway should be at the same CAC location.
- **Rule 2:** The terminating IP phone and the terminating gateway should be at the same CAC location.
- **Caveat 1:** No AAR support for any call that originates from or terminates to Cisco CTI Route Point.
- **Caveat 2:** This MAY not work with Extension Mobility; IF—the originating IP phone is in a separate location than the users ‘normal’ IP phone; why? the AAR group is on the line and the AAR CSS is on the device; so, the call will use the phone CSS to route out a local gateway but the prefixed digits will be according to the lines AAR group! works if dialing is same from any AAR group.
Agenda

- IP Telephony Deployment Models
- Cisco CallManager Dial Plan Toolkit
- Dial Plan Design Guidelines
- Conclusions
Dial Plan Design Guidelines Agenda

- Single Site Enterprise
- Multi-Site with Distributed Call Processing
- Multi-Site with Centralized Call Processing
- Tail-End Hop-Off (TEHO)
- Useful Tidbits
Single Site
Typical Route Patterns

Route Pattern
911
9.911

Route Pattern
9.[2-9]XX XXXX

Route Pattern

Route Pattern
9.011!
9.011!#

Route List
"PSTN-RL"

Discard PreDot
Discard Trailing #

Route Group
"PSTN-RG"

Local Area Code
Route Patterns
May Be Added

PSTN Gateway(s)

PSTN
Single Site
View of Partitions/Calling Search Spaces

Calling Search Spaces

- InternalOnly
- Local
- National
- International

Partitions

- Internal
- Local
- National
- International

All IP Phones, Voice Mail, Media Resources, 911 Route Pattern

External Route Patterns

Calling Search Space Assigned to IP Phone Based on Policy
Single Site Composite Dial Plan View

- **Calling Search Spaces**
  - Calling Search Space Assigned to IP Phone Based on Policy
- **Partitions**
  - Internal
    - All IP Phones
      - 911
      - 9.911
  - Local
    - 9.[2-9]XXXXXX
  - National
    - 9.1 [2-9]XX
    - [2-9]XX XXXX
  - International
    - 9.011!
  - International
    - 9.011!
    - #

- **Route Lists**
- **Route Groups**
- **Devices**
  - Route Patterns
  - PSTN

- **Calling Search**
  - Spaces Partitions
  - Route Lists
  - Route Groups
  - Devices

- **Spaces Assigned to IP Phone Based on Policy**
  - 911
  - 9.911
  - 9.011!
  - 9.011!#
Dial Plan Design Guidelines Agenda

- Single Site Enterprise
- **Multi-Site with Distributed Call Processing**
- Multi-Site with Centralized Call Processing
- Tail-End Hop-Off (TEHO)
- Useful Tidbits
Multi-Site with Distributed Call Processing
Example of Dial Plan Requirements

Primary Voice Path: IP WAN
- **Outgoing** (NY cluster): Strip “9” and deliver “14085264000” to Gatekeeper
- **Incoming** (SJ cluster): Strip all but significant 5 digits

Secondary Voice Path: PSTN
- **Outgoing** (NY cluster): Strip “9” and deliver “14085264000” to the PSTN
- **Incoming** (SJ cluster): Strip all but significant 5 digits
Multi-Site with Distributed Call Processing
Gatekeeper for Dial Plan Resolution

- Gatekeeper provides Call Admission Control in presence of multiple CallManager clusters (distributed call processing deployments)
- CallManager configured with “Anonymous Device”—uses Gatekeeper also to resolve E.164 addresses
- Lower dial plan administration, highly scalable distributed model
Multi-Site with Distributed Call Processing
Automatic Re-Route with Gatekeeper

1st Choice
ARQ
ACF
Gatekeeper

2nd Choice
ARQ
ARJ
Gatekeeper

---

gatekeeper
zone local SJC cisco.com
zone local NYC cisco.com
zone prefix SJC 140855534...
zone prefix SJC 14085557...
zone prefix SJC 131055598...

zone prefix NYC 16465551...
zone prefix NYC 131255568..
zone prefix NYC 120255524..

gw-type-prefix 1#* default-
technology
bandwidth interzone zone SJC 480
Multi-Site with Distributed Call Processing

Typical Route Patterns

Route Pattern
911
9.911

Route Pattern

Route Pattern
9.011!
9.011!#

Route Group
“PSTN-RG”

Route Group
“IPWAN-RG”

Route List
“PSTN-RL”

Route List
“IPWAN-RL”

PSTN Gateway

Anonymous Device

PSTN

IP WAN

Individual Route Patterns for Remote Corporate Sites May Be Added
Multi-Site with Distributed Call Processing
Composite Dial Plan View

Calling Search Spaces
- Internal Only
- Local
- National
- International

Calling Search Space Assigned to IP Phone Based on Policy

Partitions
- Internal
  - All IP Phones
  - 911
  - 9.911
- Local
  - 9.[2-9]XXXXXX
- National
  - 9.1[2-9]XX
  - [2-9]XX XXXX
- International
  - 9.011!
  - 9.011!#

Route Lists
- PSTN RL
- PSTN RG

Route Groups
- Route Patterns

Devices
- PSTN
- GK
- IP WAN

Calling Search Space Assigned to IP Phone Based on Policy
Dial Plan Design Guidelines Agenda

• Single Site Enterprise
• Multi-Site with Distributed Call Processing
• Multi-Site with Centralized Call Processing
• Tail-End Hop-Off (TEHO)
• Useful Tidbits
Multi-Site with Centralized Call Processing
Example of Dial Plan Requirements

- CallManager at central site, up to 10,000 IP phones per cluster
- Common PSTN access code ("9")
- 911 and PSTN calls use each site’s local gateway
- Non-overlapping extensions (*overlapping case covered later*)
Multi-Site with Centralized Call Processing
View of Partitions/Calling Search Spaces

- **Partitions**
  - PHL911
  - PHLPSTN
  - OnCluster
  - NYC911
  - NYCPSTN

- **Calling Search Spaces**
  - PHLInternal
  - PHLAllCalls
  - NYCInternal
  - NYCAllCalls

Calling Search Space Assigned to IP Phone
Based on Policy and Location

- **External Route Patterns for PHL**
- **All IP Phones, Voice Mail, Media Resources**
- **External Route Patterns for NYC**
Multi-Site with Centralized Call Processing
Composite Dial Plan View

Calling Search Spaces
- PHLPhones
- NYCPhones

Partitions
- PHL911
  - 911
  - 9.911
- PHLPSTN
  - 9.[2-9]XXXXXX
  - 9.011!
  - 9.011!#

Route Lists
- PHL PSTN

Route Groups
- NYC PSTN

Devices
- PSTN
- PHL Gateways
- NYC Gateways

Calling Search Space Assigned to IP Phone Based on Policy and Location

Space Assigned to IP Phone
- Based on Policy
- Based on Location

Calling Search View
- Spaces
- Partitions
- Route Lists
- Route Groups
- Devices
Dial Plan Design Guidelines Agenda

- Single Site Enterprise
- Multi-Site with Distributed Call Processing
- Multi-Site with Centralized Call Processing
- Tail-End Hop-Off (TEHO)
- Useful Tidbits
Tail-End Hop-Off (TEHO)
What Is it?

Calls to a Remote PSTN Number
Use the IP WAN and Terminate at the GW Closest to the Destination

1. Within a CallManager Cluster
2. Across CallManager Clusters
Tail-End Hop-Off (TEHO)  
Intra-Cluster—Seattle to San Jose

User Calls 914085551234

Route Pattern 91408[2-9]XXXXXX

Route List SE-SJ-RL

1st Choice

Route Pattern Match
No Digit Manipulation

Select Route Group
Based on Priority

Route Group SJ-RG

Route Group SE-RG

2nd Choice

Route Through SJ GW
as a Result Call is Local
CCM Strips off ‘9’
CAC May Reject Call

Route Through SJ GW
as a Result Call is Local
CCM Strips off ‘9’
CAC May Reject Call

Backup Path
Use SE GW
CAC Not Required

SJ Gateway Presents
Call to PSTN in SJ

(408) 555 1234
San Jose

PSTN

GW Strips ‘9’
Then Presents Call to PSTN in SE

San Jose

Seattle
Tail-End Hop-Off (TEHO)
Intra-Cluster—Route Patterns for Seattle

Route Pattern
9.1 408 [2-9]XX XXXX

Route Patterns
9.011!, 9.011!

Route Patterns
911, 9.911
9.[2-9]XX XXXX

Route List
“SE-SJ-RL”

Route List
“SE-SE-RL”

Route Group
“SJ-RG”

Route Group
“SE-RG”

San Jose Gateway

Seattle Gateway

PSTN

PSTN

1st Choice
2nd Choice
Tail-End Hop-Off (TEHO)
Intra-Cluster—Composite Dial Plan for Seattle

**Calling Search Spaces**
- **Internal_SE**
- **Local_SE**
- **National_SE**
- **International_SE**

**Partitions**
- **Internal**
  - IP Phones, VM
- **SE_911**
- **SE_Local**
  - 9.0[2-9]XXXXXX
- **SE_National**
  - 9.1 408 [2-9]XX XXXX
- **SE_International**
  - 9.011!
  - 9.011!#

**Route Lists**
- **SE-SE RL**
- **SE-SJ RL**

**Route Groups**
- **SE-RG**
- **SJ-RG**

**Devices**
- **PSTN**
- **Seattle Gateways**
- **San Jose Gateways**

**Calling Search Spaces**
- Calling Search Space Assigned to IP Phone Based on Policy and Location

**Route Lists**
- 2nd Choice
- 1st Choice

**Route Groups**
- 2nd Choice
- 1st Choice
Tail-End Hop-Off (TEHO)
Inter-Cluster—San Jose to New York

Step 1
Route Pattern
9.1 646 [2-9]XX XXXX
1st Choice
Anonymous Device
SJ Gateway

Step 2
Gatekeeper
San Jose CallManager Cluster
San Jose Gateway
Step 3
New York CallManager Cluster
New York Gateway
Route Pattern
1 646 [2-9]XX XXXX
NY Gateway

(646) 555-6789
Calls 9 1 646 5556789
Gatekeeper zone prefix NY 1646........
Tail-End Hop-Off (TEHO)
Inter-Cluster—Composite Dial Plan for San Jose

Calling Search Spaces
- Internal_SJ
  - Internal
    - IP Phones, VM
- Local_SJ
  - SE_Local
    - 9.[2-9]XXXXXX
- National_SJ
  - SE_National
      - 9.1 408 [2-9]XX XXXX
- International_SJ
  - SE_International
    - 9.011!
      - 9.011!

Partitions
- Internal
- SE_911
  - 911
  - 9.911
- SE_Local
  - 9.[2-9]XXXXXX
- SE_National
  - 9.1 408 [2-9]XX XXXX
- SE_International
  - 9.011!
    - 9.011!

Route Lists
- SJ-SJ RL
- SJ-WAN RL

Route Groups
- SJ-RG
- WAN-RG

Devices
- PSTN
- San Jose Gateways
- Anonymous Device (Gatekeeper)
Tail-End Hop-Off (TEHO)
Inter-Cluster—Dial Plan for New York

- Note: To avoid routing loops, do not include partitions that contain IP WAN routes in the “From_IP_WAN” Calling Search Space
Dial Plan Design Guidelines Agenda

• Single Site Enterprise
• Multi-Site with Distributed Call Processing
• Multi-Site with Centralized Call Processing
• Tail-End Hop-Off (TEHO)
• Useful Tidbits
Dial Plan Design Guidelines Agenda

- Single Site Enterprise
- Multi-Site with Distributed Call Processing
- Multi-Site with Centralized Call Processing
- Tail-End Hop-Off (TEHO)
- Useful Tidbits
Dial Plan Entries Have a Weight!

• Dial plan complexity is a factor to consider

• In essence, each DN, route pattern, translation pattern, etc... has a weight

• Each server platform has a maximum capacity (i.e.: can handle a maximum dial plan weight)

• This is another metric, separate from the device weights
Weights per Entry

- **Subscriber dial plan weights**
  - IP phone or other dialable device (excluding line appearance) = 5
  - Unique line appearance = 5
  - Shared line appearance = 4
  - Reachability by line appearance = 3

- **Global dial plan weights**
  - Route pattern = 2
  - Translation pattern = 1
## Weight Capacities per Platform

<table>
<thead>
<tr>
<th>Total Dial Plan Weight Units on Subscriber Server</th>
<th>Server Memory Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 15,000</td>
<td>512 MB of RAM Installed</td>
</tr>
<tr>
<td>Up to 35,000</td>
<td>768 MB of RAM Installed</td>
</tr>
<tr>
<td>Up to 70,000</td>
<td>1 GB of RAM Installed</td>
</tr>
<tr>
<td>Up to 140,000</td>
<td>2 GB of RAM Installed</td>
</tr>
</tbody>
</table>
Useful Tidbits
Configuring a Security Hotline (PLAR)

Create Partition **SECURITY**

Create **HOTLINE** CSS Containing **SECURITY** Partition

Create Translation Pattern Matching `<NONE>`, Called Party Transformation Mask Equal to 1000, CSS Set for Internal. (Contains Partition with Security Phone)

Create Door Phone with CSS set to **HOTLINE**
Useful Tidbits
Mapping DID to 5 Digit Extension—Prefix Calling # with 9

Must Prepend Access Code “9” to Match Translation Patterns

Incoming

Called: 9140852.6XXXX [Discard PreDot] Prefix 9
Called: 9121271.4XXXX [Discard PreDot] Prefix 9
Called: 9195296.7XXXX [Discard PreDot] Prefix 9

Internal

Calling: 9 XXX XXX XXXX
Called: XYYYY

1 Translation Pattern per DID Range
Useful Tidbits
Staff Calls Other Internal Staff Member via DID

Calling Search Spaces

National

Internal

Partitions

Called: XXXXX    Calling: 9XXXXX

Called:                  Calling:
9140852.6XXXX [Discard PreDot] Prefix 9
9121271.4XXXX [Discard PreDot] Prefix 9
9195296.7XXXX [Discard PreDot] Prefix 9

1 Translation Pattern per DID Range
Agenda

• IP Telephony Deployment Models
• Cisco CallManager Dial Plan Toolkit
• Dial Plan Design Guidelines
• Conclusions
Conclusions
General Recommendations

• **Keep it simple!**

• Plan for future growth

• Use the Anonymous Device when more than 2 CallManager clusters are present

• Normalize DNs to the full E.164 when using Gatekeeper for dial plan resolution
Conclusions
Summary—What Did We Cover?

• Enterprise IP Telephony dial plan operation—the tools and how to use them
• Design recommendations for the different deployment models:
  Single Site
  Multi-Site WAN with Distributed Call Processing
  Multi-Site WAN with Centralized Call Processing

For More Information:
www.cisco.com/go/srnd
For More Information about Dial Plan and IPT in General, See Latest SRND!

In order to assist enterprise customers in building an efficient, reliable, and scalable network, Cisco has developed a set of documents with detailed design and implementation guidance for various Cisco networking solutions. These Solution Reference Network Design Guides (SRNDs) provide proven best practices to build out a Cisco AWMD network infrastructure. The SRNDs available are listed below. Please visit the site often as new SRNDs are posted periodically.

- **Implementing 802.1w and 802.1s in Campus Networks (Implementation Guide)**
- **Identity-Based Network Access Control and Policy Enforcement (Implementation Guide)**
- **IP Multicast**
- **Data Center Networking: Infrastructure Architecture**
- **Data Center Networking: Securing Server Farms**
- **Data Center Networking: Optimizing Server and Application Environments**
- **Data Center Networking: Integrating Security, Load Balancing, and SSL Services using Service Modules**
- **Data Center Networking: Internet Edge Design**
- **Data Center Networking: Distributed Data Centers**
- **IP Telephony for CallManager 3.3**
- **IP Telephony for CallManager 3.1.3.2**
- **IP Videoconferencing**
- **IP Contact Center**
- **Quality of Service**

For More Information about Dial Plan and IPT in General, See Latest SRND!
Recommended Reading

Cisco CallManager Fundamentals: A Cisco AVVID Solution
ISBN: 1-58705-008-0
Please Complete Your Evaluation Form

Dial Plan Design