What Does a Unified Dial Plan Look Like?

William Bell,
Chesapeake Netcraftsmen

wjb@netcraftsmen.net

October, 2009

Copyright 2009

Agenda

- **Dial Plan Elements Overview**
  An introduction to basic elements of the Cisco Unified Communications Manager (CUCM) solution
- **Evolution of a Dial Plan**
  Using real situations as examples, we will touch on issues with some common dial plan implementations and how architectures must evolve
- **Dial Plan Changes in CUCM 7x**
  Significant features have been introduced with CUCM 7x that facilitate greater adaptability and scalability within a dial plan

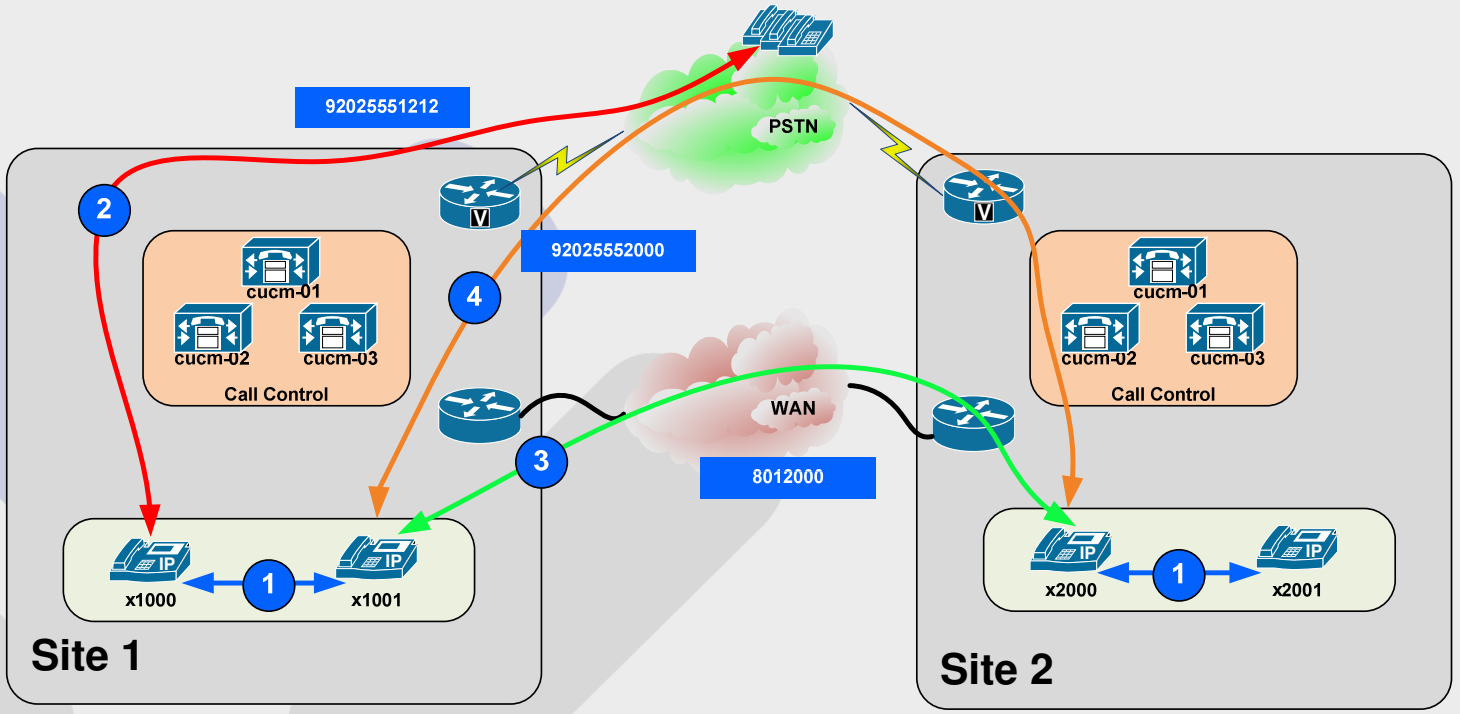
Copyright 2009

Dial Plan Basics

The Cliff Notes Version

Copyright 2009

Call Types and Routing



1. **OnNet/IntraCluster:** Destination directory number (DN) is registered with local CUCM cluster
2. **OffNet:** DN is routed through PSTN
3. **InterCluster:** DN exists on another CUCM cluster
4. **Alternate Routing:** Allowing calls to follow alternate paths

Copyright 2009

Digit Analysis: Patterns

Pattern	Description	Example
0,1,2,3,4,5,6,7,8,9,*,#	Match exactly one keypad button	
X	Any single digit 0-9	72XX matches 7200 to 7299
[xyz]	Exactly one of any KP buttons in brackets	7[2468]00 matches 7200, 7400, 7600, 7800
[x-z]	Exactly one of any digit between x and z, inclusive	7[2-5]00 matches 7200, 7300, 7400, 7500
[^x-z]	Any digit that is NOT between x and z, inclusive	7[^2-8]00 matches 7000, 7100, 7900
!	One or more digits in the range of 0-9	9! Matches 91, 9123, 91234, 912345678123
?	Matches zero or more occurrences of previous digit	91?4105551212 matches 94105551212, 914105551212
+	Matches one or more occurrences of previous digit	91+ matches 91, 911, 9111, 91111
\+	The + also is a special character in CUCM 7.x that is used for e.164 dialing strings	+14105551212 is the e.164 number for station in 410 NPA of the NANP
@	Numbering plan macro	9.@

Copyright 2009

Digit Analysis: More Examples

*2000	An exact match for pattern *2000 (asterisk is a digit!)
2XXX#	Any pattern 2000# to 2999# (the # has to be dialed)
9.911	Matches 9911, the dot "." is used for digit manipulation
9.1[2-9]XX[2-9]XXXXXX	Matches long distance dialing strings in NANP
9.[2-8]11	Matches PSTN service codes in NANP
9.[^19]11	Same as above, though less intuitive
9.011!	International dialing prefix for North America, will match any number of digits after the 011 (e.g. 9.011330856778)
1[2-5]6[189]X	Matches 12610, 12611, 15689, etc.
1[^16789]6[^0234567]X	Invalid. Only one circumflex character is allowed per string
<blank>	Meaning no digits. This is allowed, and will be an immediate match/route. A PLAR like application
9.1?410[2-9]XXXXXX	Matches 94105551212, 914105551212, and 91111111114105551212 – yeah, that's right
\+!	New in CUCM 7x, matches any e.164 number string

Copyright 2009

Digit Analysis: Pattern Types

Pattern Type	Description
Device (Directory Number)	Pattern assigned to station line on IP phone, CTI Port, CTI Route Point
Route Pattern	Pattern used to send calls to any Off Cluster location
Translation Pattern	Similar to Route Patterns in form and function but keeps call On Cluster
Voicemail Port	Pattern assigned to voicemail port
Message Waiting	Pattern used by voicemail applications to toggle MWI
Hunt Pilot	Patterns used to direct callers to hunt groups/line groups
Call Pickup	Patterns that “link” line DNs together and allow users to grab a call to any DN in their pickup group
Call Park / Directed Call Park	Patterns that allow users to place callers on hold in a way that can be retrieved by another phone line
Intercom	Like DNs but application specific pattern for intercom
Intercom Translations	Like translation but applied to intercom configs only

Copyright 2009

Digit Analysis: Pattern Types (2)

Pattern Type	Description
Conference	Meet me line numbers that users can leverage to open up multi-party conference lines
Voicemail Pilot	Pilot numbers that are used to control routing of 'messages' button and allow easier admin of call forwarding to VM
Transformation Patterns	Used to normalize calling party information when presented to end station. Objective is to minimize need for called user to manipulate digits on return calls
Application Dial Rules	Used by applications like Click-to-call widget, CUCM Assistant, and Web Dialer to manipulate digits to conform to dial plan
Directory Lookup Dial Rules	Used by Attendant Console application to assist in mapping an existing directory name to calling party number
SIP Dial Rules	Used by SIP end points (line side) to enable SIP phones to be "aware" of the basic dial plan rules of the CUCM cluster and process user digits efficiently

Copyright 2009

Digit Analysis: Process Example

User Action: <offhook>

CUCM Actions:

- Provide Dial Tone
- Wait for "Off Hook to First Digit" timeout

Configured Patterns

8111	Might Match
8211	Might Match
8[23]XX	Might Match
8[^4-9]X9	Might Match
821	Might Match
82?1	Might Match
8[0-4]XX	Might Match
82!	Might Match

Copyright 2009

Digit Analysis: Process Example

User Action: dial 8

CUCM Actions:

- Break Dial Tone
- Wait for interdigit timeout
- Digit Analysis: 8

Configured Patterns

8111	Might Match
8211	Might Match
8[23]XX	Might Match
8[^4-9]X9	Might Match
821	Might Match
82?1	Might Match
8[0-4]XX	Might Match
82!	Might Match

Copyright 2009

Digit Analysis: Process Example

User Action: dial 2

CUCM Actions:

- Wait for interdigit timeout
- Keep Waiting as more digits may result in a different match
- Digit Analysis: 82

Configured Patterns

8111	No Match
8311	No Match
8[23]XX	Might Match
8[^4-9]X9	Might Match
821	Might Match
82?1	Might Match
8[0-4]XX	Might Match
82!	Match! + More

Copyright 2009

Digit Analysis: Process Example

User Action: dial 1

CUCM Actions:

- Wait for interdigit timeout
- Keep Waiting as more digits may result in a different match
- Digit Analysis: 821

Configured Patterns

8111	No Match
8311	No Match
8[23]XX	Might Match
8[^4-9]X9	Might Match
821	Match!
82?1	Match!
8[0-4]XX	Might Match
82!	Match! + More

Copyright 2009

Digit Analysis: Process Example

User Action: dial 1

CUCM Actions:

- Wait for interdigit timeout
- Keep Waiting as more digits may result in a different match
- Digit Analysis: 8211

Configured Patterns

8111	No Match
8311	No Match
8[23]XX	Match!
8[^4-9]X9	No Match
821	No Match
82?1	No Match
8[0-4]XX	Match!
82!	Match! + More

Copyright 2009

Digit Analysis: Process Example

User Action: <wait>

CUCM Actions:

- Interdigit timeout occurs
- Digit Analysis: 8211

Which Pattern is chosen?

Configured Patterns

8111	No Match
8311	No Match
8[23]XX	Match!
8[^4-9]X9	No Match
821	No Match
82?1	No Match
8[0-4]XX	Match!
82!	Match! + More

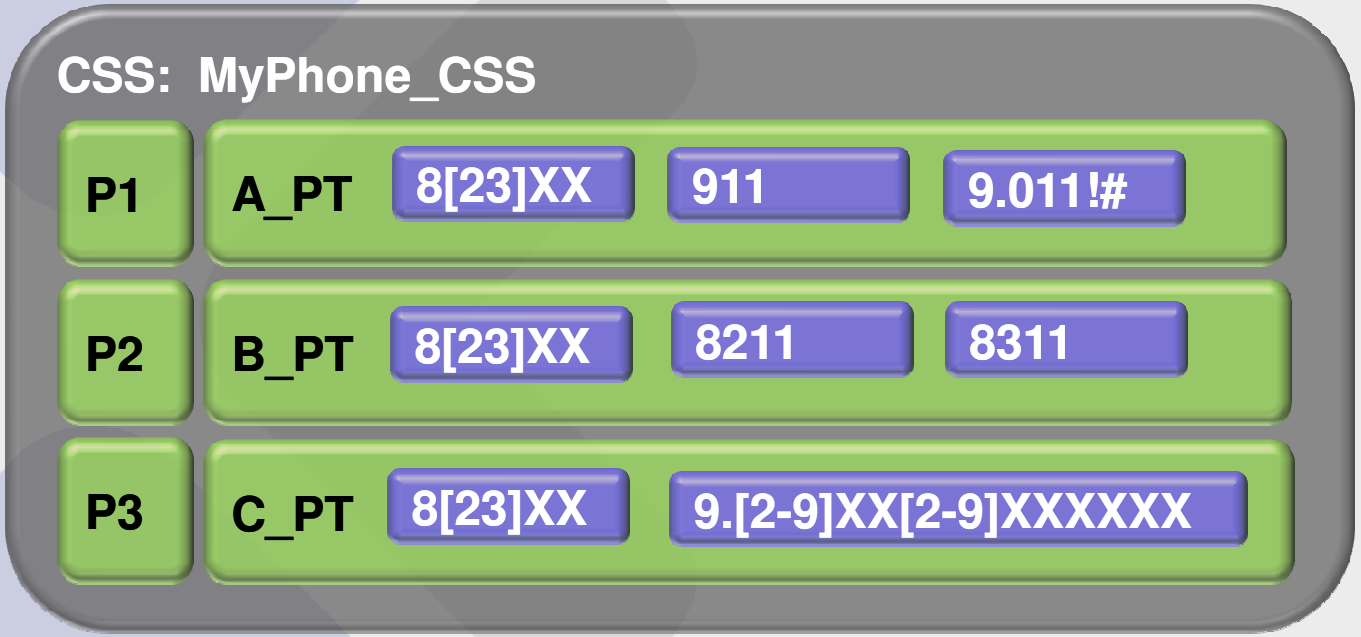
8[23]XX	200 Potential Matches
8[0-4]XX	500 Potential Matches
82!	100 Potential Matches

With "!" there are ∞number of matches. However, CUCM only looks at potential matches given number of digits dialed!

Copyright 2009

Partitions and Calling Search Spaces

- Patterns are given **context** with Partitions and Calling Search Spaces (CSS)
- A Partition (PT) is a container that holds patterns
- A CSS is a container that holds Partitions

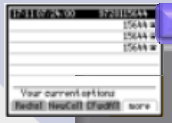


Copyright 2009

Partitions and Calling Search Spaces

CSS is assigned to any object that can Originate or Redirect a call setup

Phones
CSS: CSS1
- A_PT
- B_PT



Lines
CSS: CSS2
- B_PT

Gateways
CSS: CSS3
- B_PT
- A_PT

Translations
CSS: CSS4
- A_PT

Partitions are assigned to any object that has a digit pattern.

A_PT

8301, 8302, 8303	Lines
84XX, 75XX, 76^4X	Translations
9.911, 9.[2-9]XXXXXX, 9.1[2-9]XX[2-9]XXXXXX	Route Patterns

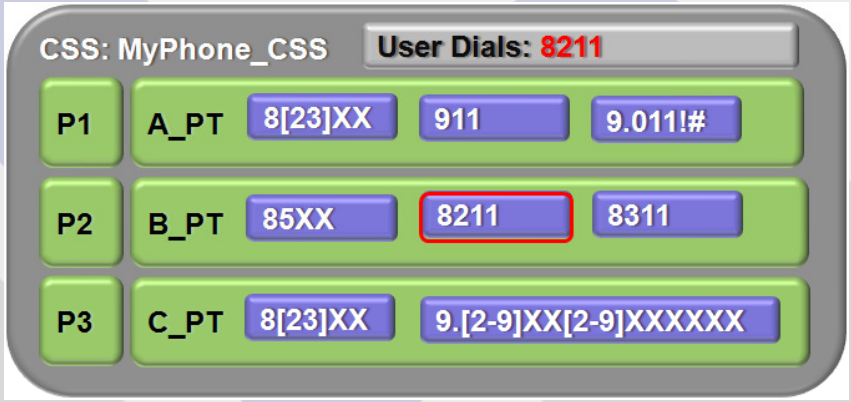
B_PT

7630, 5000, 5100	CTI RP/Ports
61XX, 62XX	Special (MML Call Pickup)
5055, 5056	VM Ports

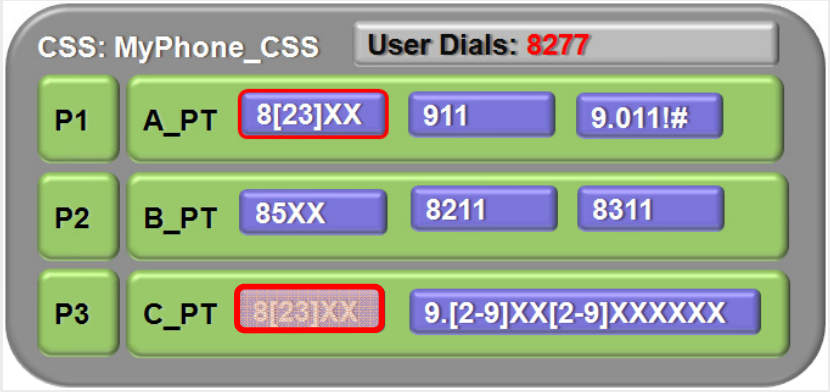
Copyright 2009

Digit Analysis: CSS+Partitions

Longest Match Wins!
No matter what the partition order is, the longest digit match wins!

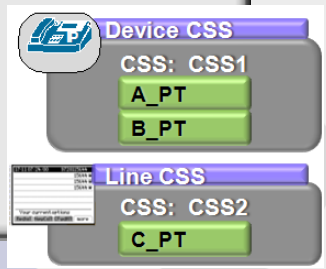


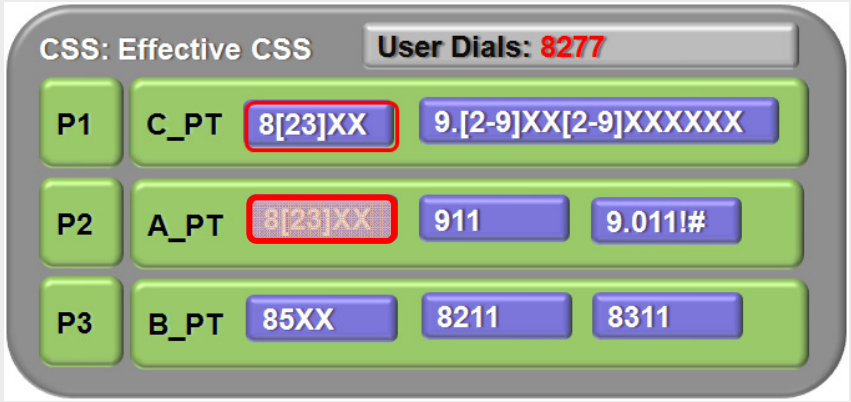
Partition Priority Determines Tie Breaker!
If two patterns present an identical match, then partition priority plays a role



Line CSS and Device CSS are additive!

The effective CSS when a user goes off hook to call is the concatenation of the line level CSS and device level CSS. Notice what happens now when we dial 8277.





Copyright 2009

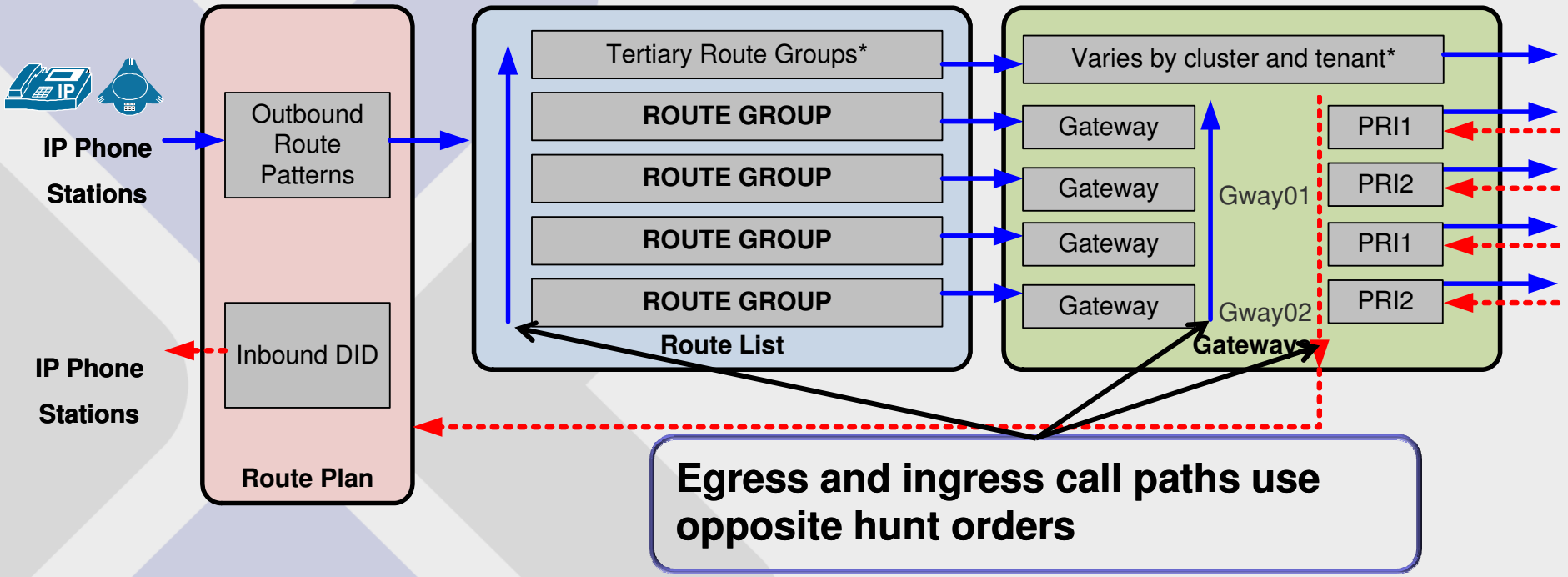
<none>

- There is a special route partition: <none>
  - <none> PT is visible from all Calling Search Spaces
- There is a special CSS: <none>
  - <none> CSS contains only the <none> PT
- Using the <none> partition can lead to unexpected call routing behavior
- Mixing <none> CSS and partitions is living on borrowed time
- Note that in pre-6x releases, having a Call Forward All (CFA) CSS of <none> would cause the CUCM forwarding engine to use the calling party's CSS to route the call

Copyright 2009

I Found a Match, Now What?

- Route Patterns use Route Lists (RL) to start selecting a call path (traditional)
- Route Lists contain Route Groups (RG)



- Features in CUCM 7x will be discussed later

Copyright 2009

The Evolution of a Dial Plan

Everything should be made as simple as possible, but not simpler.

Copyright 2009

Case Studies

- **Case Study: Class of Restriction (COR)**
  Device Level vs. Line Level COR options, the first evolution taken by Cisco in their "advanced dial plan" education series
- **Case Study: Multi-tenant Dial Plan**
  What happens when you must provide different tenant groups completely different abbreviated dialing solutions in a non-uniform dial plan
- **Case Study: Dial Plan Hierarchy**
  Why should one try to put some structure into their dial plan design

Copyright 2009

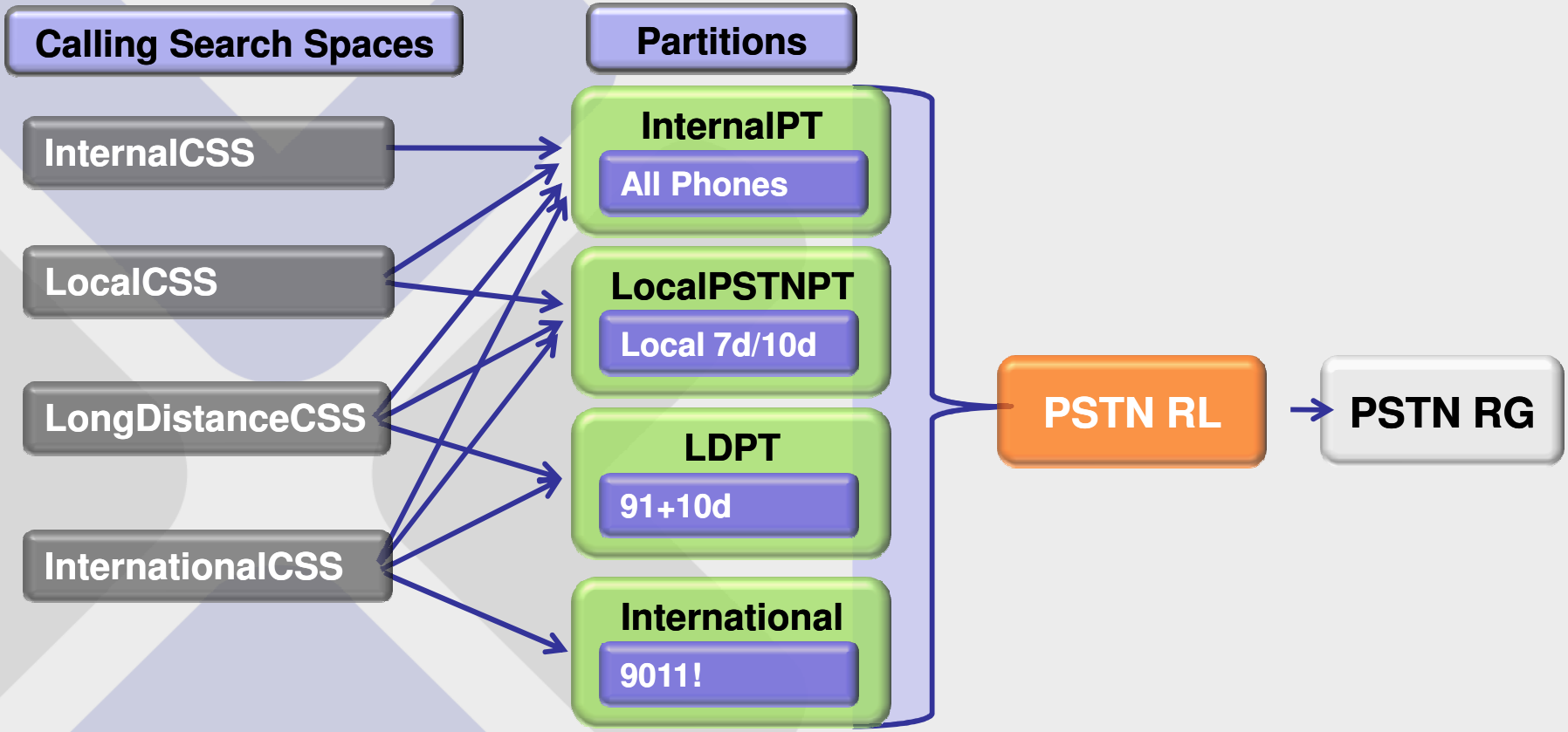
Evolution of a Dial Plan

Case Study: Class of Restriction (COR)

Copyright 2009

A Case Study: Class of Restriction (COR)

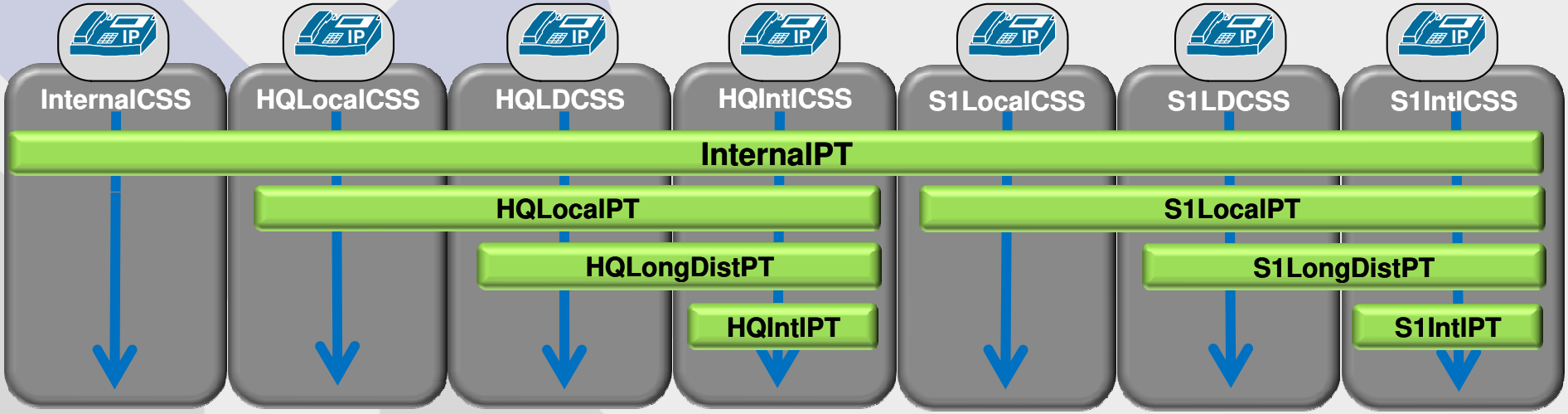
The traditional Class of Restriction approach was to implicitly "block" access to digit patterns by creating COR classes which only included what a user could dial.



Copyright 2009

A Case Study: Class of Restriction (COR)

This may be fine for a deployment with one site, but what if you have multiple sites with different gateways, route groups, route lists?



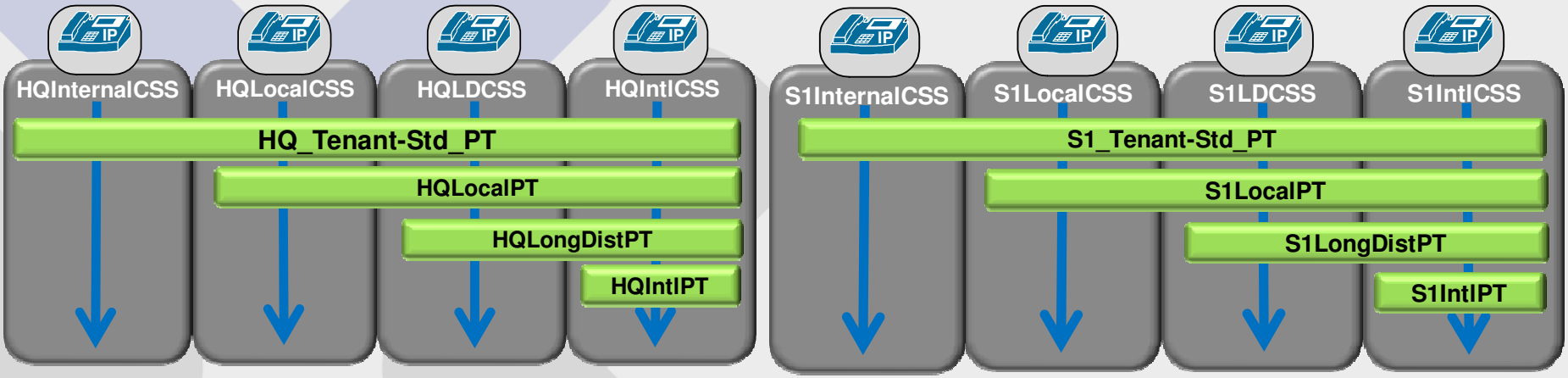
The CSS's required is a factor of N sites * 3 plus the InternalCSS used by all phones.

- **5 sites require 16 CSS configurations**
- **10 sites require 31 CSS configurations**

Copyright 2009

A Case Study: Class of Restriction (COR)

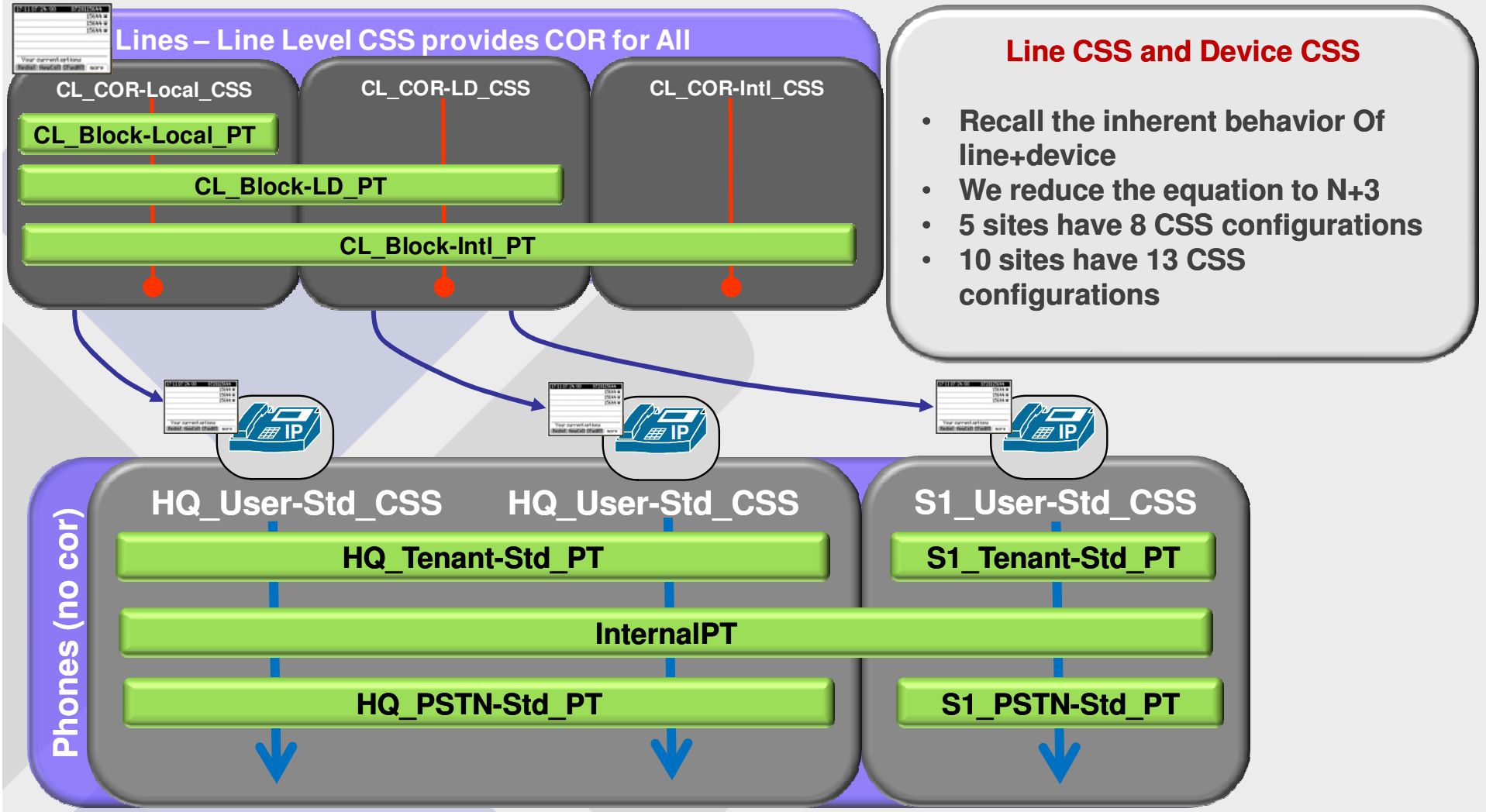
What happens when you have a need to allow local sites to reach their office attendants by dialing "0"? Then you need to have an HQInternalPT and a S1InternalPT, along with the associated CSS. So, (N*4) CSS's are needed.



- A deployment with 5 sites has at least 20 CSS configurations
- A deployment with 10 sites has at least 40 CSS configurations
- What about services that are shared across all sites?
- What if you wanted to add Forced Authorization Codes to this solution?
- What about Extension Mobility?

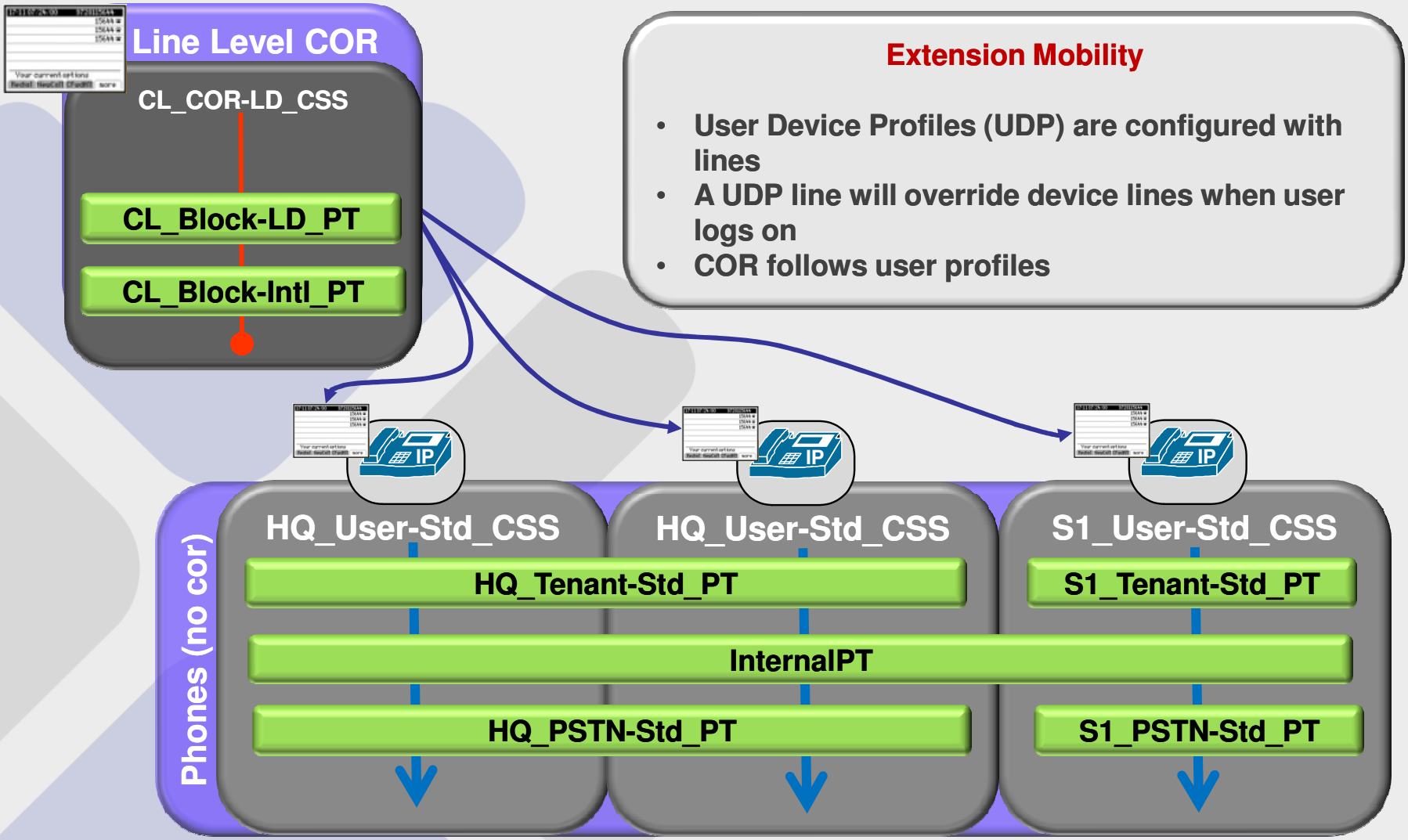
Copyright 2009

A Solution: Class of Restriction (COR)



Copyright 2009

A Solution: Class of Restriction (COR)



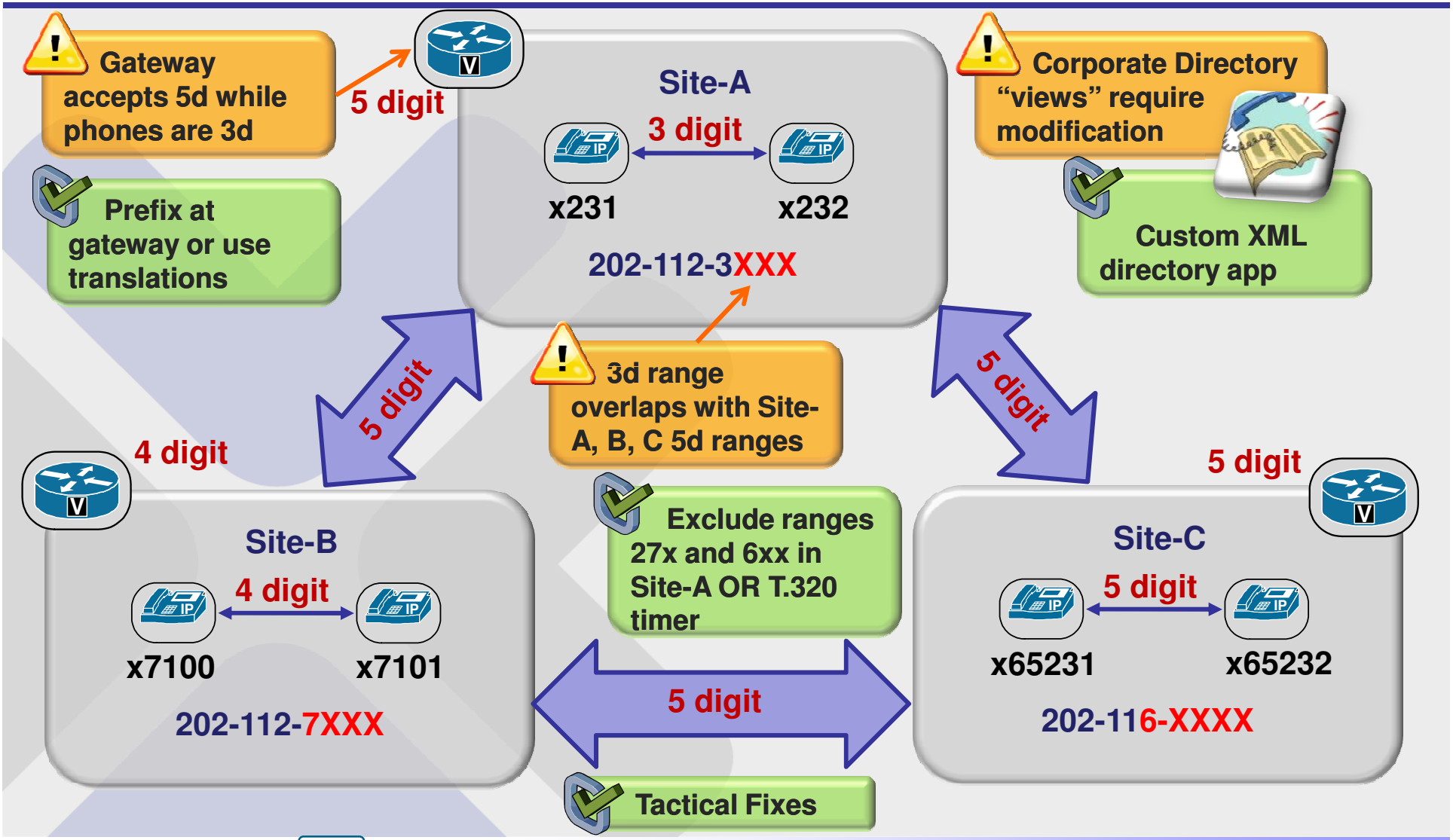
Copyright 2009

Evolution of a Dial Plan

Case Study: Multi-tenant Dial Plan

Copyright 2009

A Case Study: Multi-tenant Dial Plan



Copyright 2009

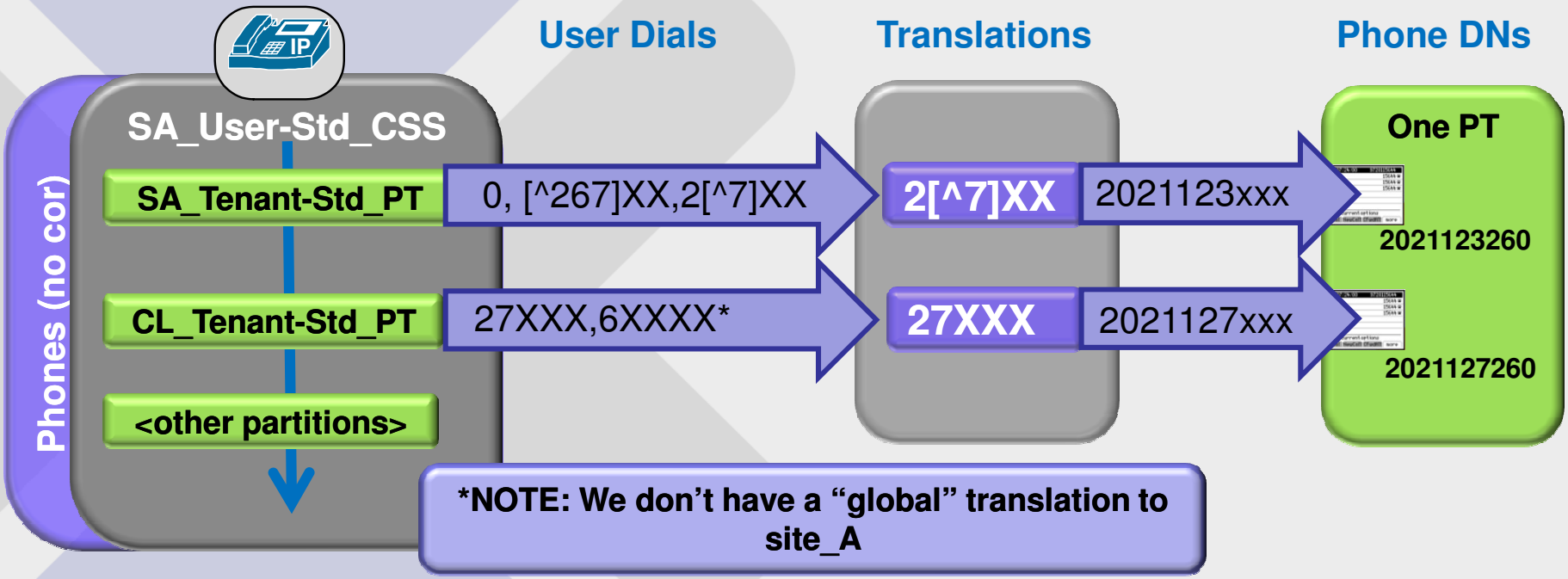
A Solution: Multi-tenant Dial Plan

Future Challenges

Engineering
- Wants a uniform dial plan
- Wants to centralize services like VM
- Needs to interoperate with Centrex/PBX

Business
- Wants to minimize impact on users
- Plans to keep expanding
- Minimize costs with centralized services

One Aspect of Solution: Variable Length OffNet Dialing (VLOD) with Flat Addressing



Copyright 2009

A Solution: Multi-tenant Dial Plan

The Ingredients

Directory Number Digit Strings	Use a digit string standard that is guaranteed unique: - Site code method 8SSSHHHH - NANP method NPANXXHHHH - E.164 method \+! (e.g. +14105551212)
Directory Numbers Assign to a Single PT	Scalability for application features (e.g): - Multi-tenant MWI - Presence - Time of Day routing
DN Partition not Directly Visible from Calling Station	Required if you want to also support local abbreviated dialing translations and for other reasons
Translation Patterns are Your Friend	Translations are handy tactical tools and absolutely necessary when building a modular and scalable dial plan design

Copyright 2009

A Solution: Multi-tenant Dial Plan

Handy Info

- Use Line Labels to "trick" users
- The Placed Calls directory will use what was dialed and not the translated pattern
- Learn to use Dialed Number Analysis (DNA) tool
- For "private" or "soft" extensions, consider using leading digit of 0 or 1 in the NPA or NXX field of a NANP number: these numbers are excluded from geographic or service assignment

Other Considerations

- Interoperability and exchanging Calling, Called, and Redirect party information with external systems like Voicemail, non-Cisco PBX, Intercluster trunk, and Centrex
- Call origination points other than IP Phones (e.g. VM, Contact Center, PSTN)
- Corporate Directory(ies)

Copyright 2009

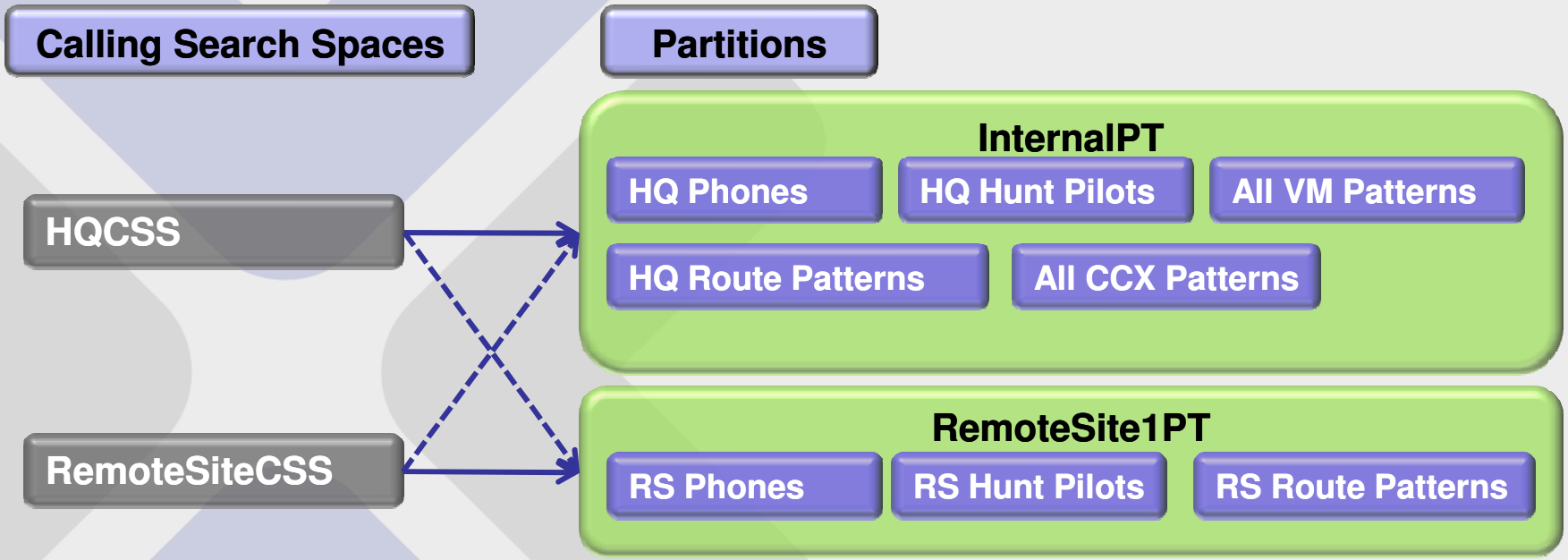
Evolution of a Dial Plan

Case Study: Dial Plan Hierarchy

Copyright 2009

A Case Study: Dial Plan Hierarchy

Not a topic that gets adequate attention. Scenario: Each remote site has its own CSS and Partitions. Phones at a remote site are in RS PT but all sites can see all PTs. Finally, pattern types/functions are combined in same partitions.

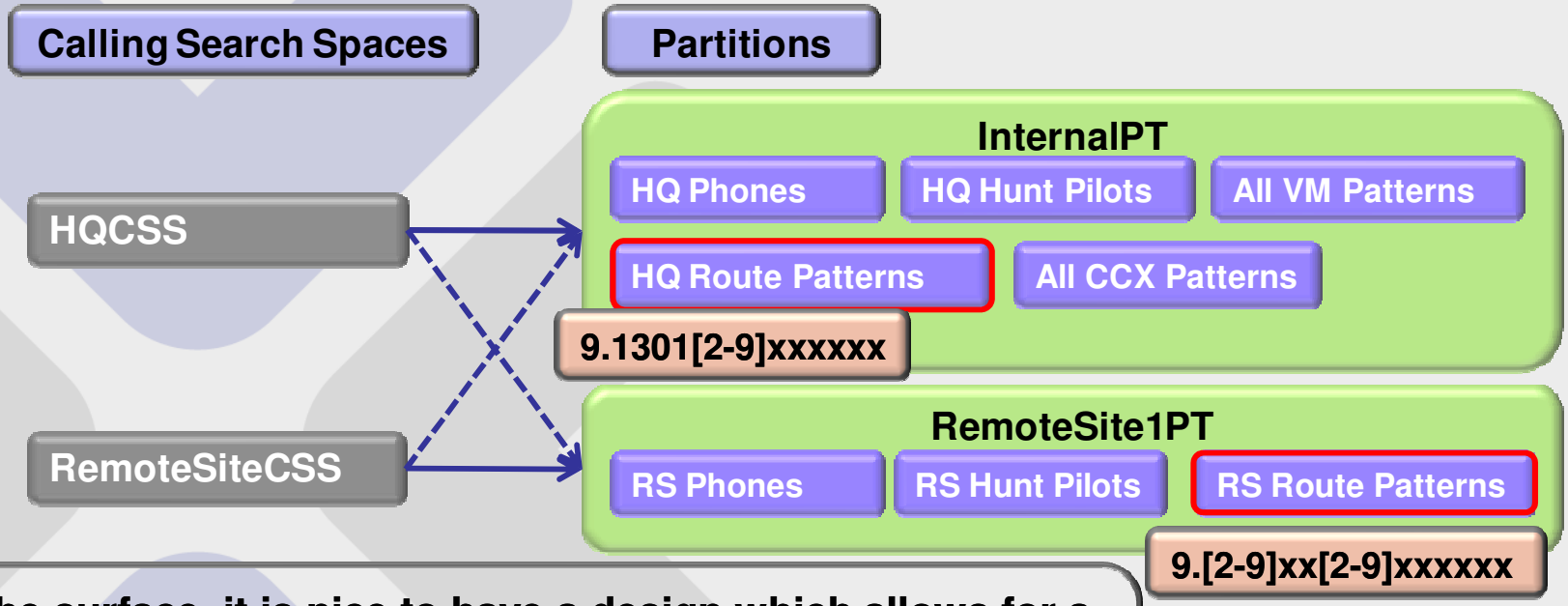


Copyright 2009

A Case Study: Dial Plan Hierarchy

Why is this an issue?

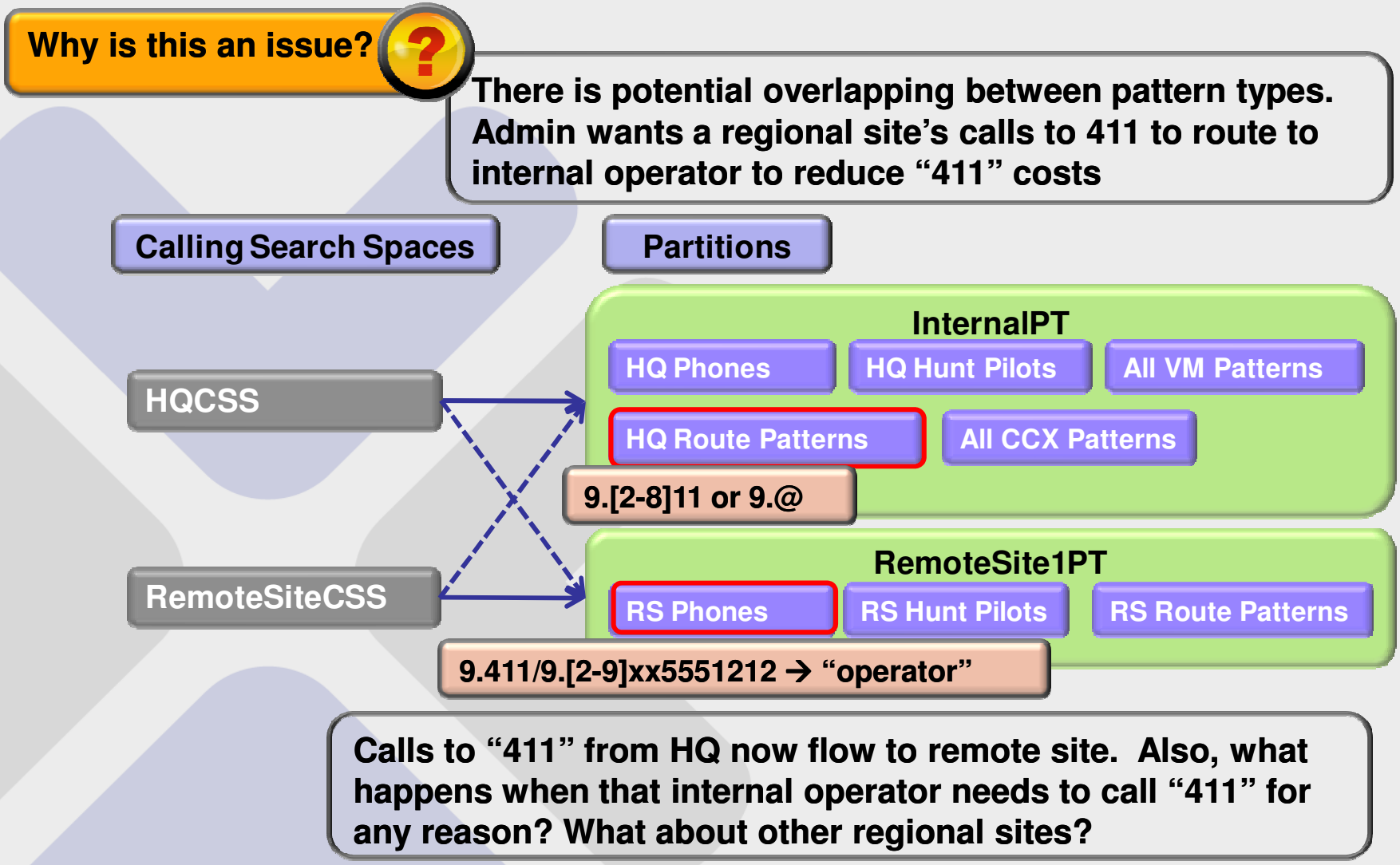
There is potential overlapping with route patterns. Admin inadvertently adds a more specific pattern to allow callers with LD restriction to call 301 NPA in HQ.



On the surface, it is nice to have a design which allows for a single configuration step to override "defaults". But what if you had 5+ sites and you don't want calls to start flowing to HQ for the 301 NPA?

Copyright 2009

A Case Study: Dial Plan Hierarchy

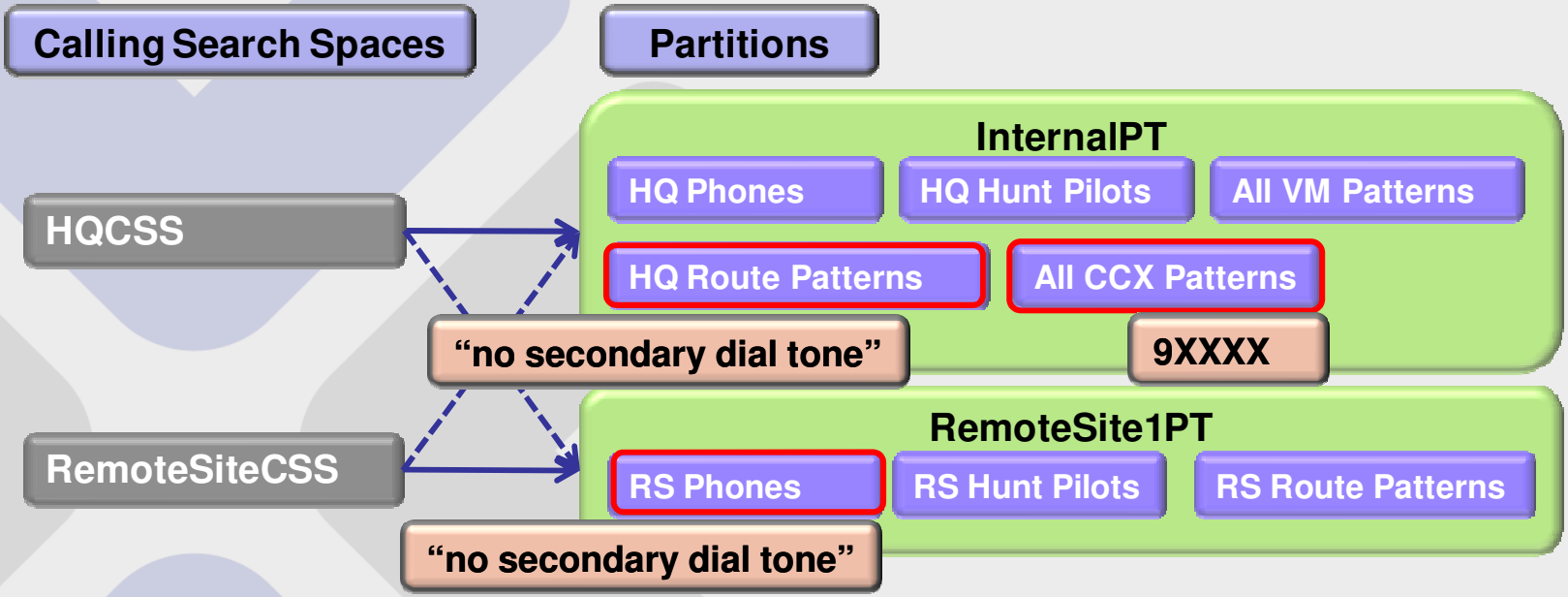


Copyright 2009

A Case Study: Dial Plan Hierarchy

Why is this an issue?

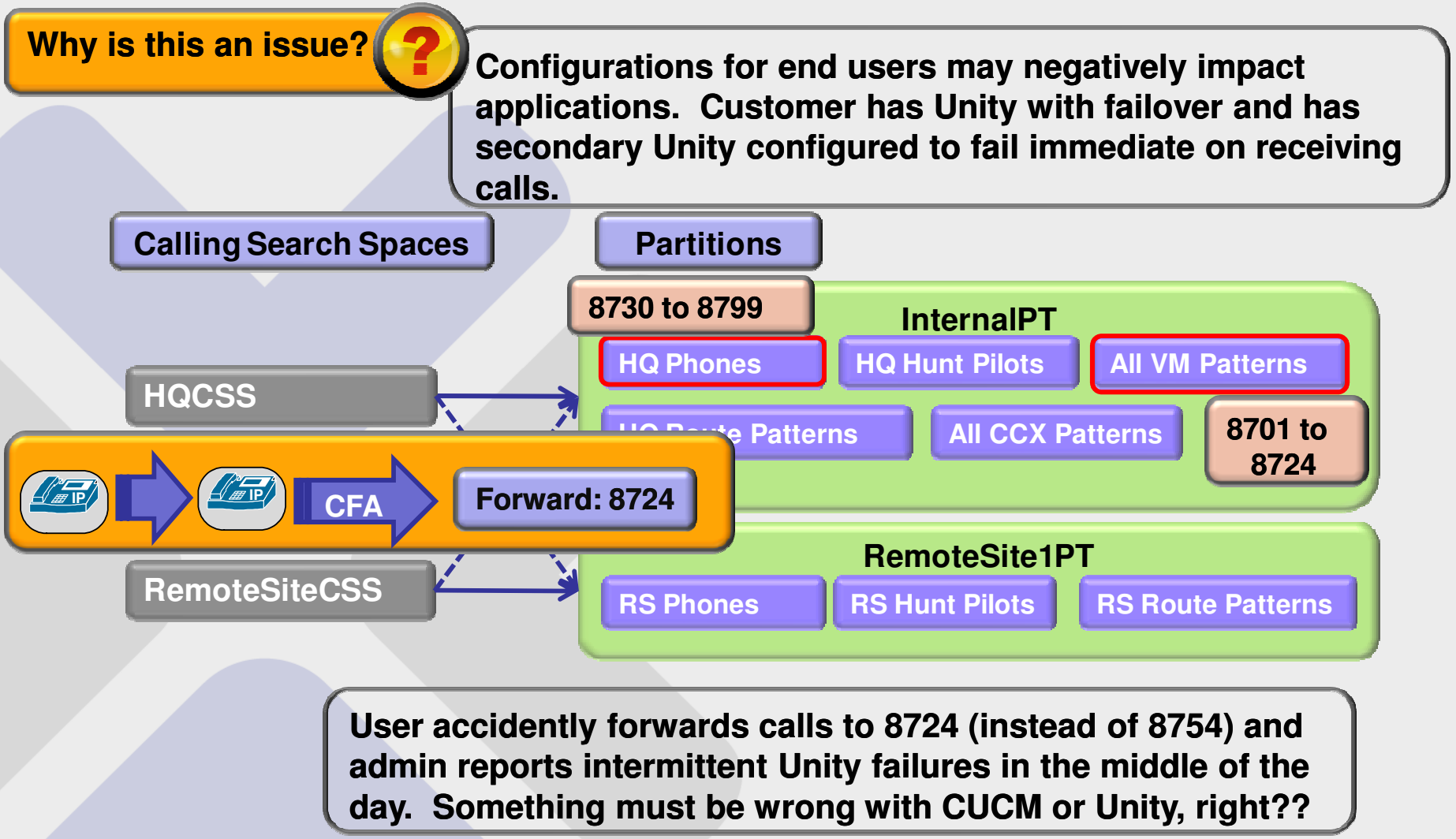
Configurations on an application may affect the end user community? Admin decided to use "non-DID" range of 9XXXX for CCX ports.



Secondary dial tone is provided by CUCM when all patterns that match a dial digit have this option checked. This option is only available on Route Patterns and translations.

Copyright 2009

A Case Study: Dial Plan Hierarchy

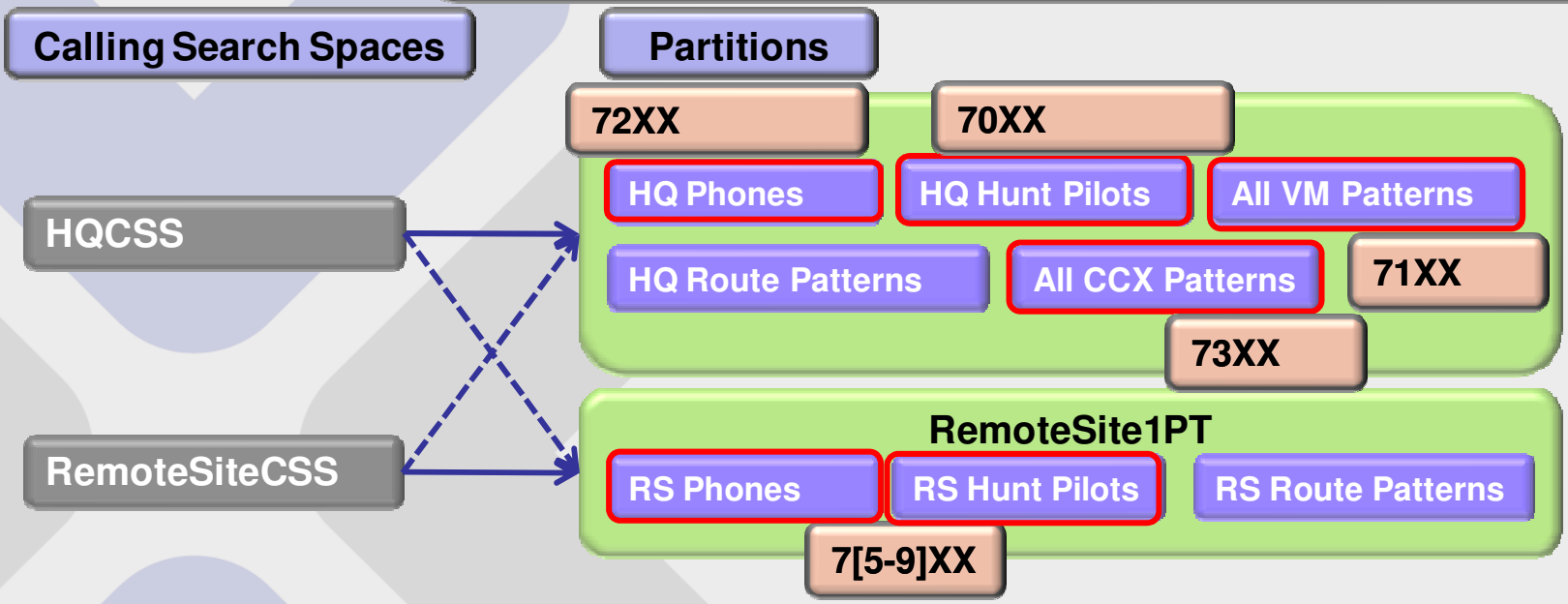


Copyright 2009

A Case Study: Dial Plan Hierarchy

Why is this an issue?

On initial build, admin thought that 7XXX would never be a supported DID range and assigned this as an "internal" extension range. Then one day, a new site comes on and 0xxx, 7xxx, and 9xxx are all that is available.



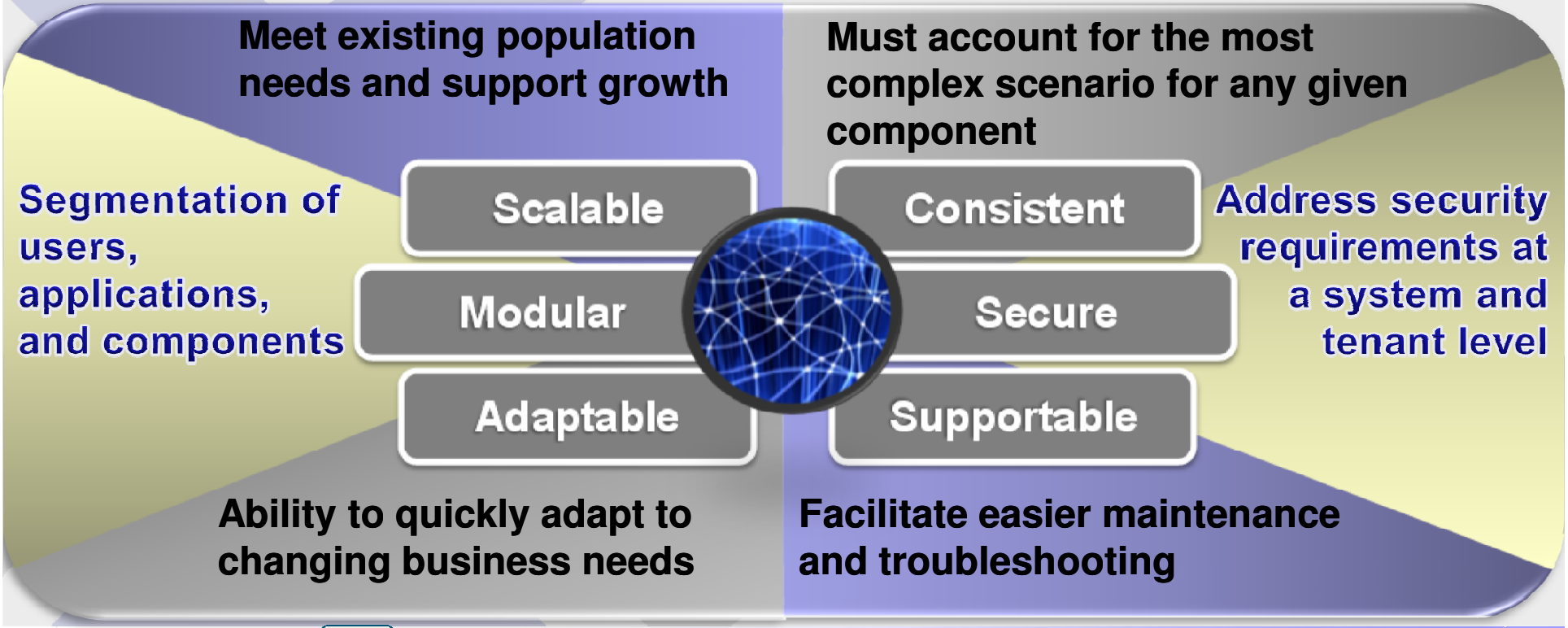
There are options, but just like this slide, none are pretty and all require some heavy lifting.

Copyright 2009

Solution: Dial Plan Hierarchy

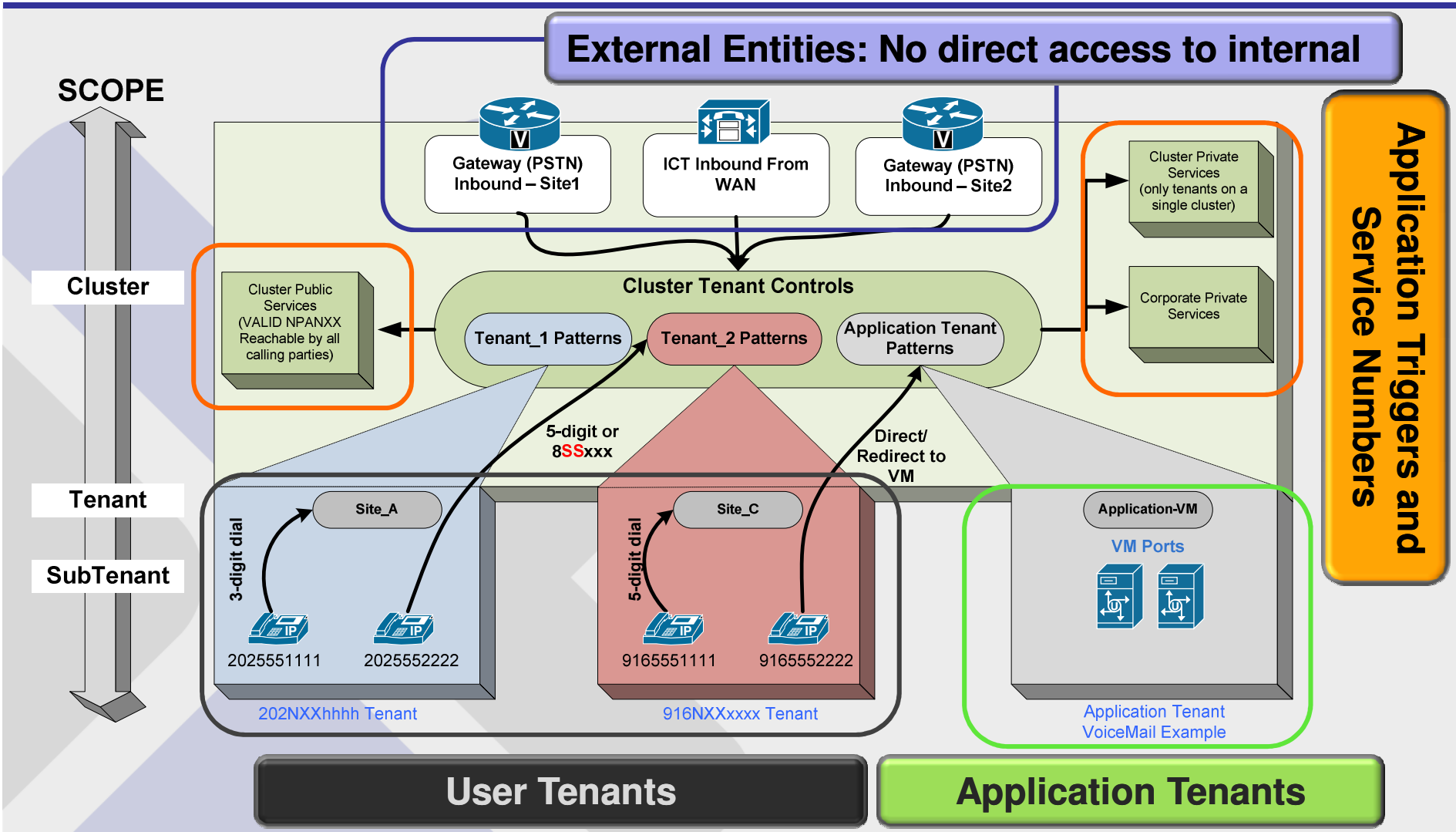
At some point in time a dial plan solution has to be more than pushing digits between plastic. It should enable the business, not restrict it.

First Step: Define Objectives



Copyright 2009

Solution: Dial Plan Hierarchy

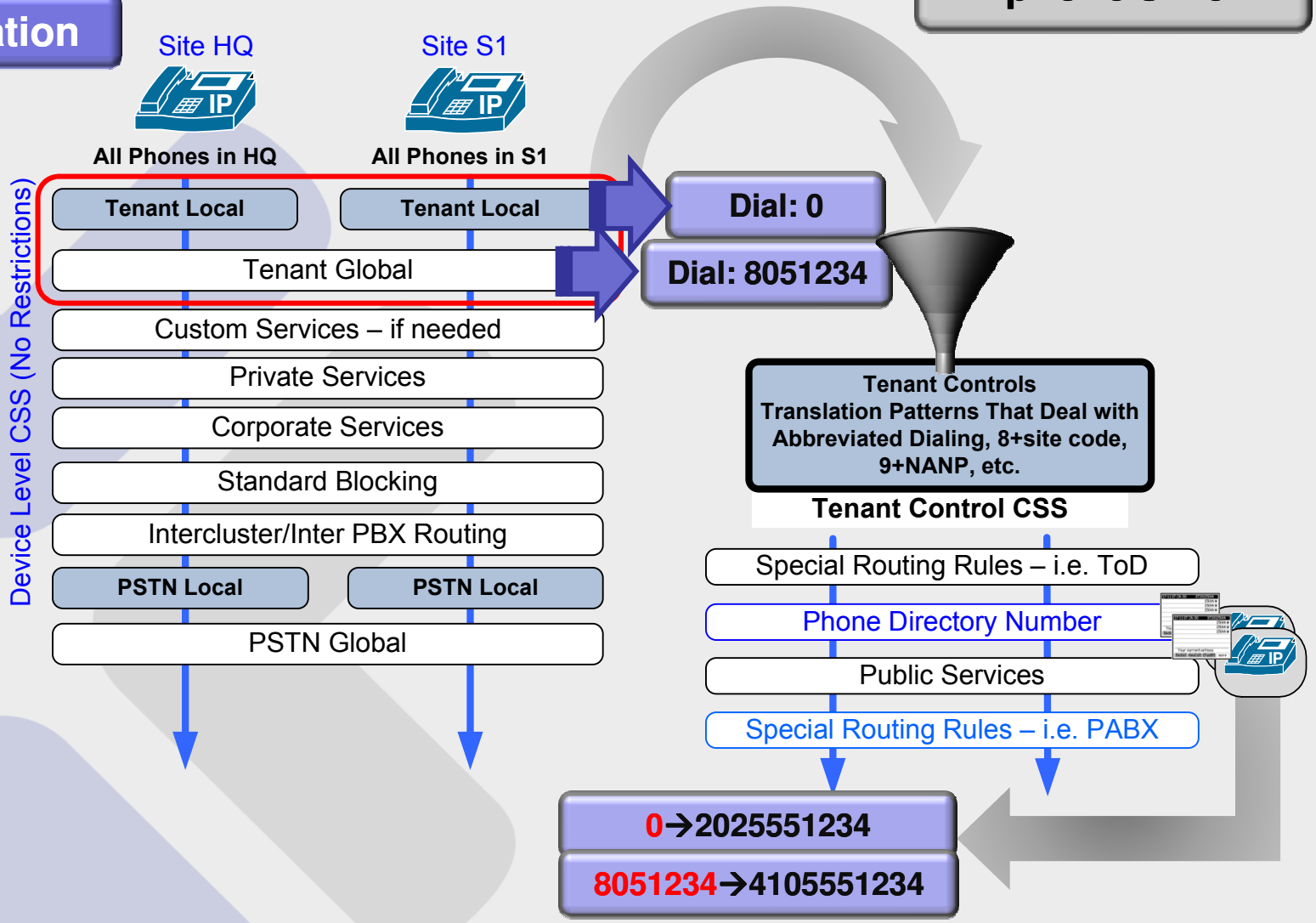


Copyright 2009

Solution: Dial Plan Hierarchy

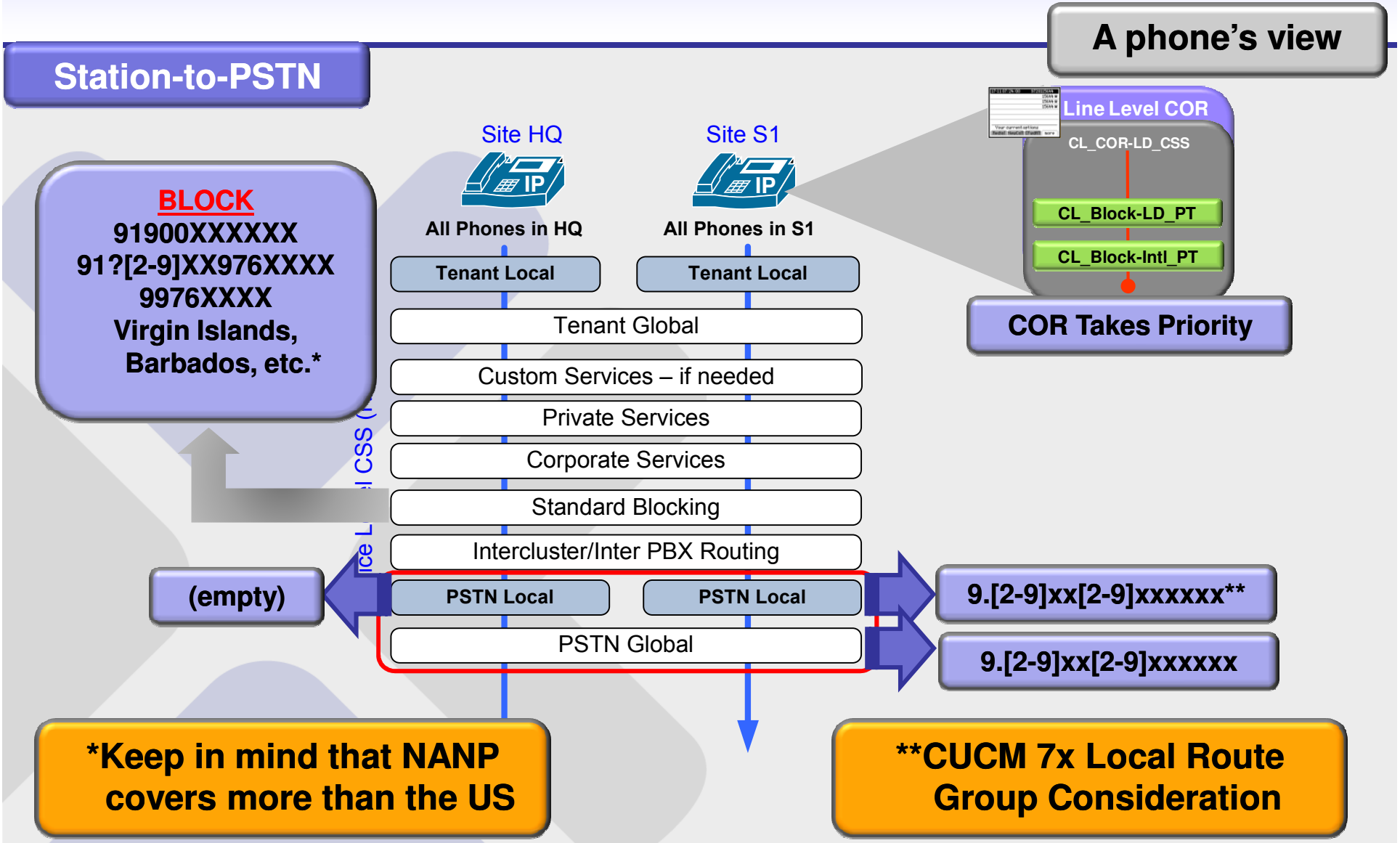
Station-to-Station

A phone's view



Copyright 2009

Solution: Dial Plan Hierarchy

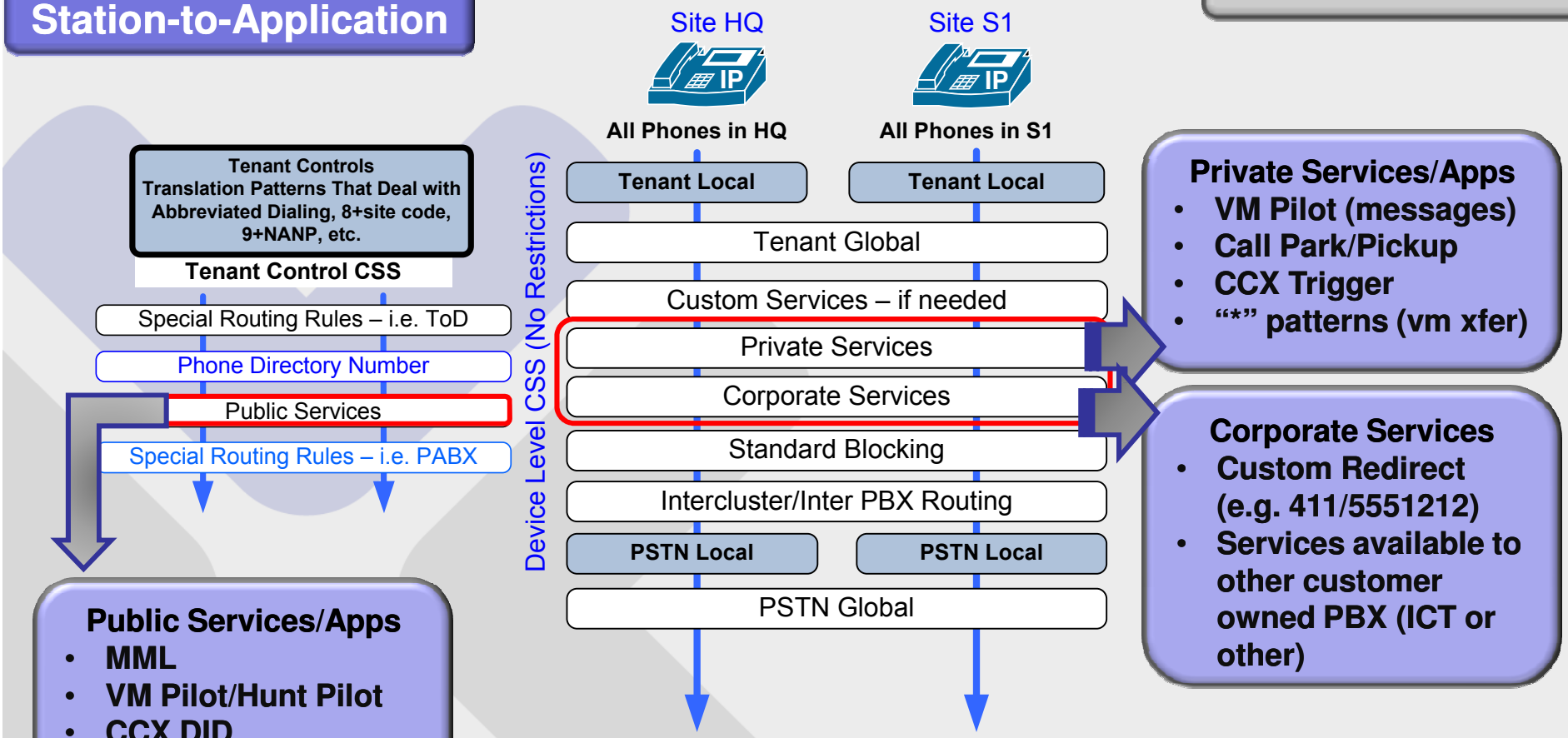


Copyright 2009

Solution: Dial Plan Hierarchy

A phone's view

Station-to-Application

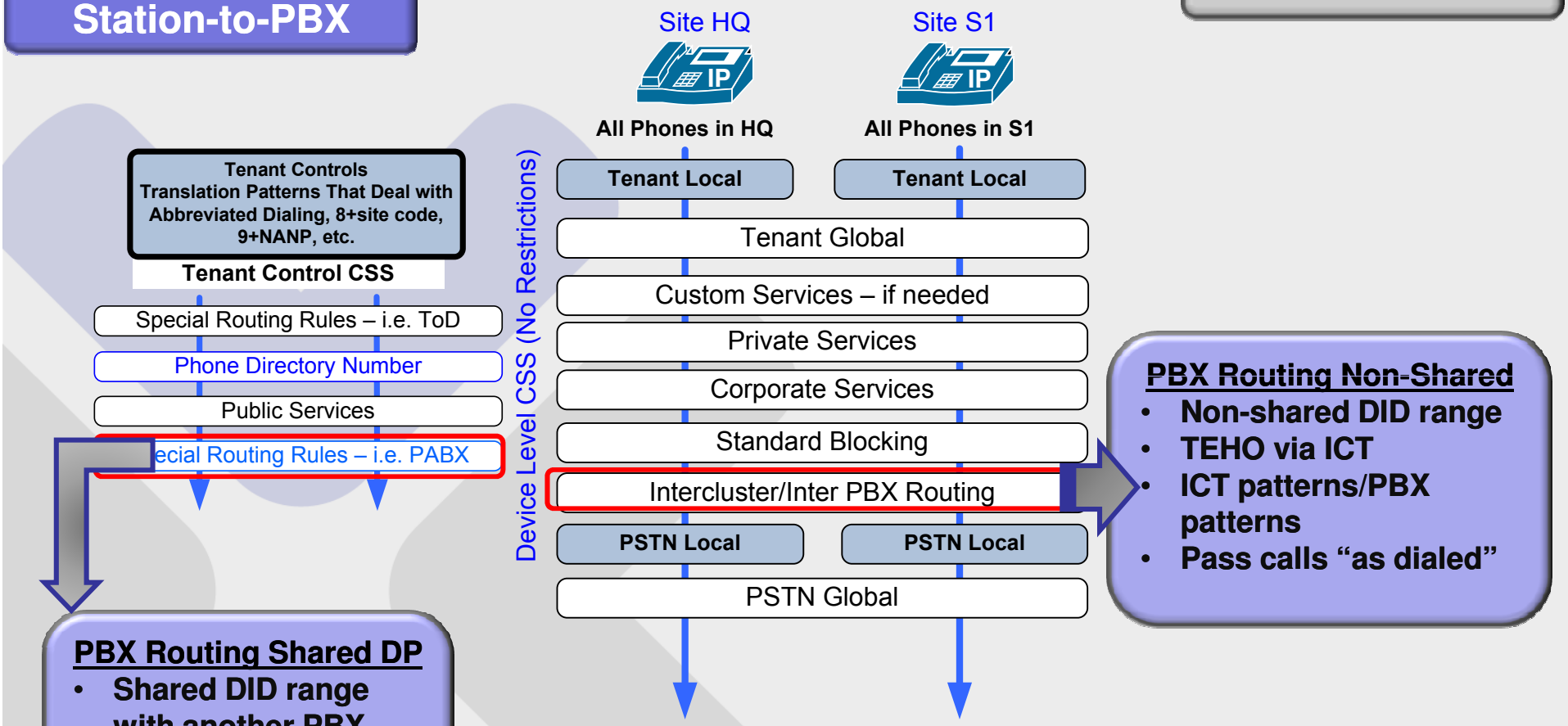


Copyright 2009

Solution: Dial Plan Hierarchy

A phone's view

Station-to-PBX



PBX Routing Non-Shared

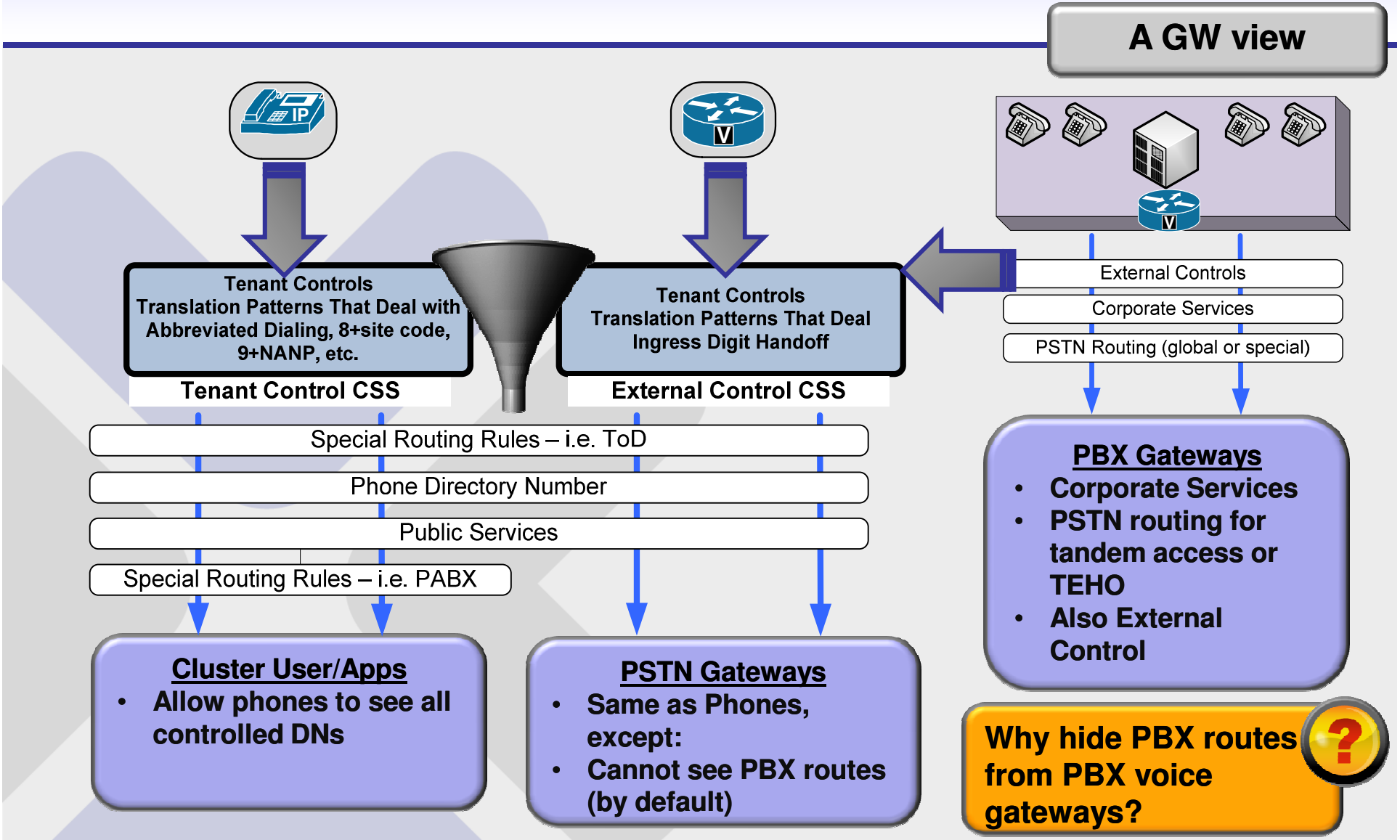
- Non-shared DID range
- TEHO via ICT
- ICT patterns/PBX patterns
- Pass calls "as dialed"

PBX Routing Shared DP

- Shared DID range with another PBX
- Apply Tenant Control rules
- Route

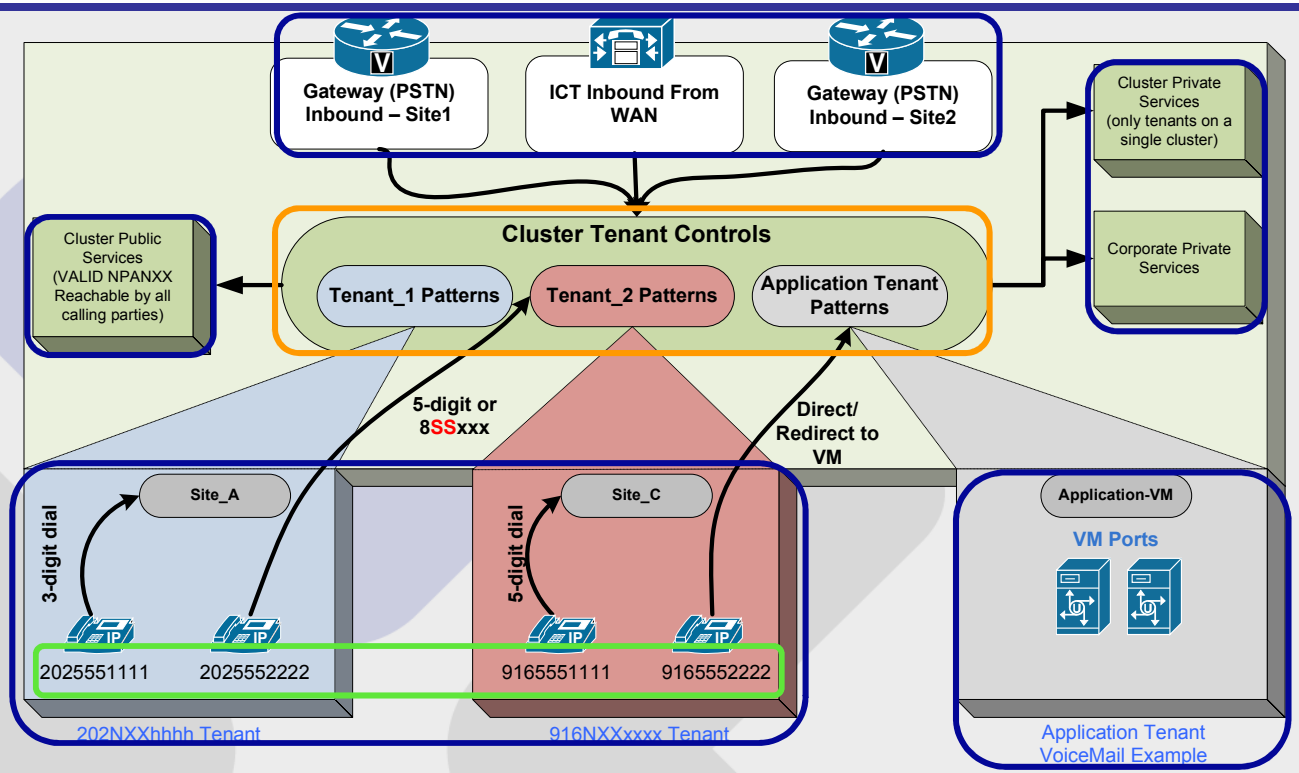
Copyright 2009

Solution: Dial Plan Hierarchy



Copyright 2009

Solution: Dial Plan Hierarchy



We conceptually group our dial plan elements. "Everything has a home."

We configure patterns to control access to/from a tenant

We leverage flat addressing for all applications and user stations

We define rules for handling calls flowing in, through, and out of the system and apply them consistently. In doing so, we find that the "core" dial plan stays consistent, only the numbers change.

Copyright 2009

Dial Plan Changes in CUCM 7x

Imagination is more important than knowledge. Knowledge is limited, imagination encircles the world

Copyright 2009

Dial Plan and CUCM 7x

- **Local Route Groups**
  The ability to dictate egress call routing behavior based on physical location of the calling device provides a key feature to the CUCM 7x new dial plan approach
- **Support for E.164 "global" format with + dialing**
  CUCM 7x now supports "+" dialing from speed dials, applications, call lists, and directories. This provides CUCM with more options for integration and interoperability with applications like MS OCS and future position for end-to-end SIP carrier services
- **Support for ingress/egress calling and called party transformations**
  Used in conjunction with "+" dialing (or without!), this feature allows for more granular control on localizing number presentation for ingress and egress calling

Copyright 2009

Dial Plan and CUCM 7x

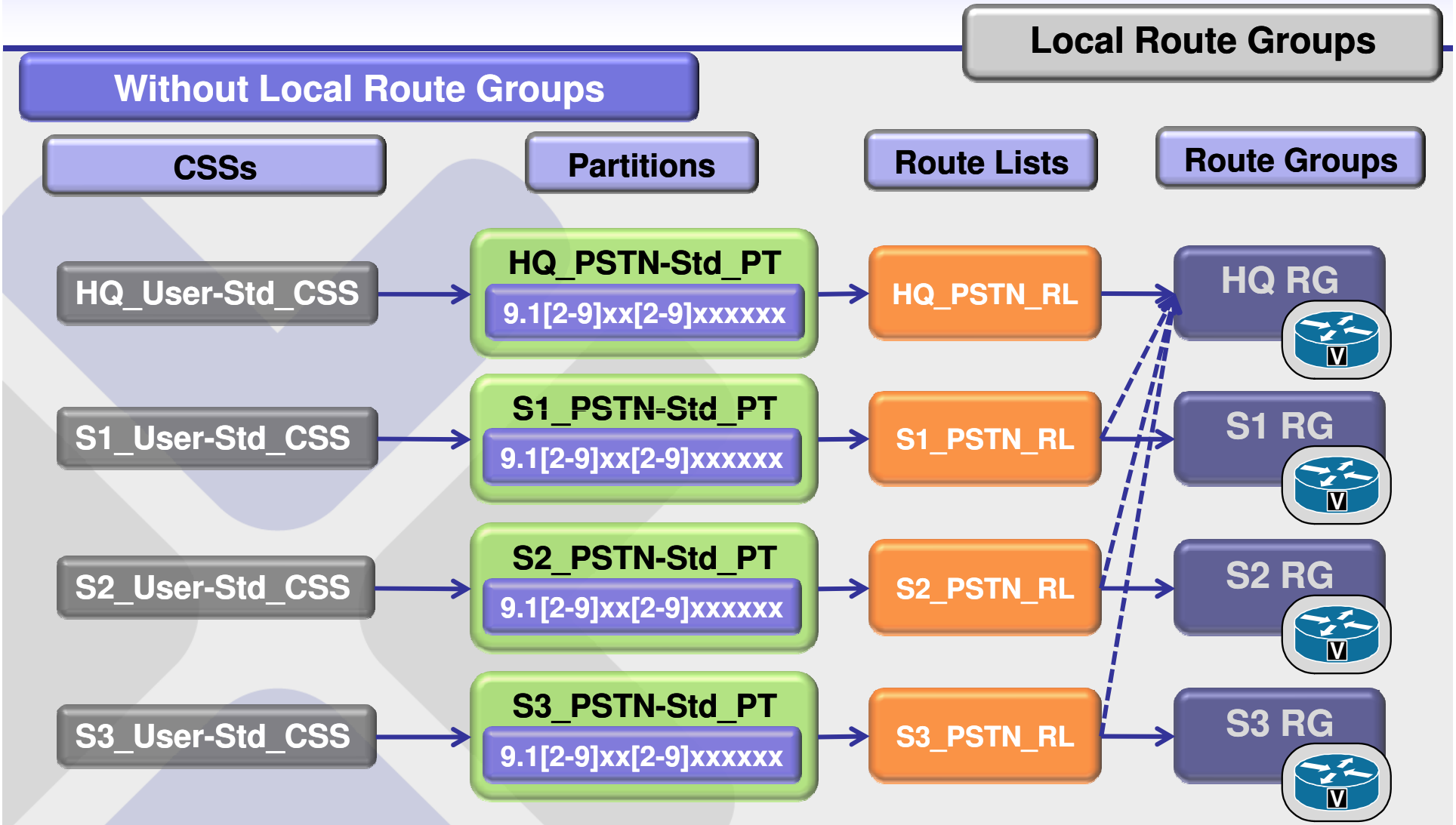
Local Route Groups

The Concept

- Leverage an existing configuration parameter (Device Pool) to attach site-specific call routing rules
- Add a new option to existing configuration parameter (Route List) that is a pointer to site-specific routing rules
- Objective: Endow a single route pattern with the ability to route calls to different locations based on the device placing the call

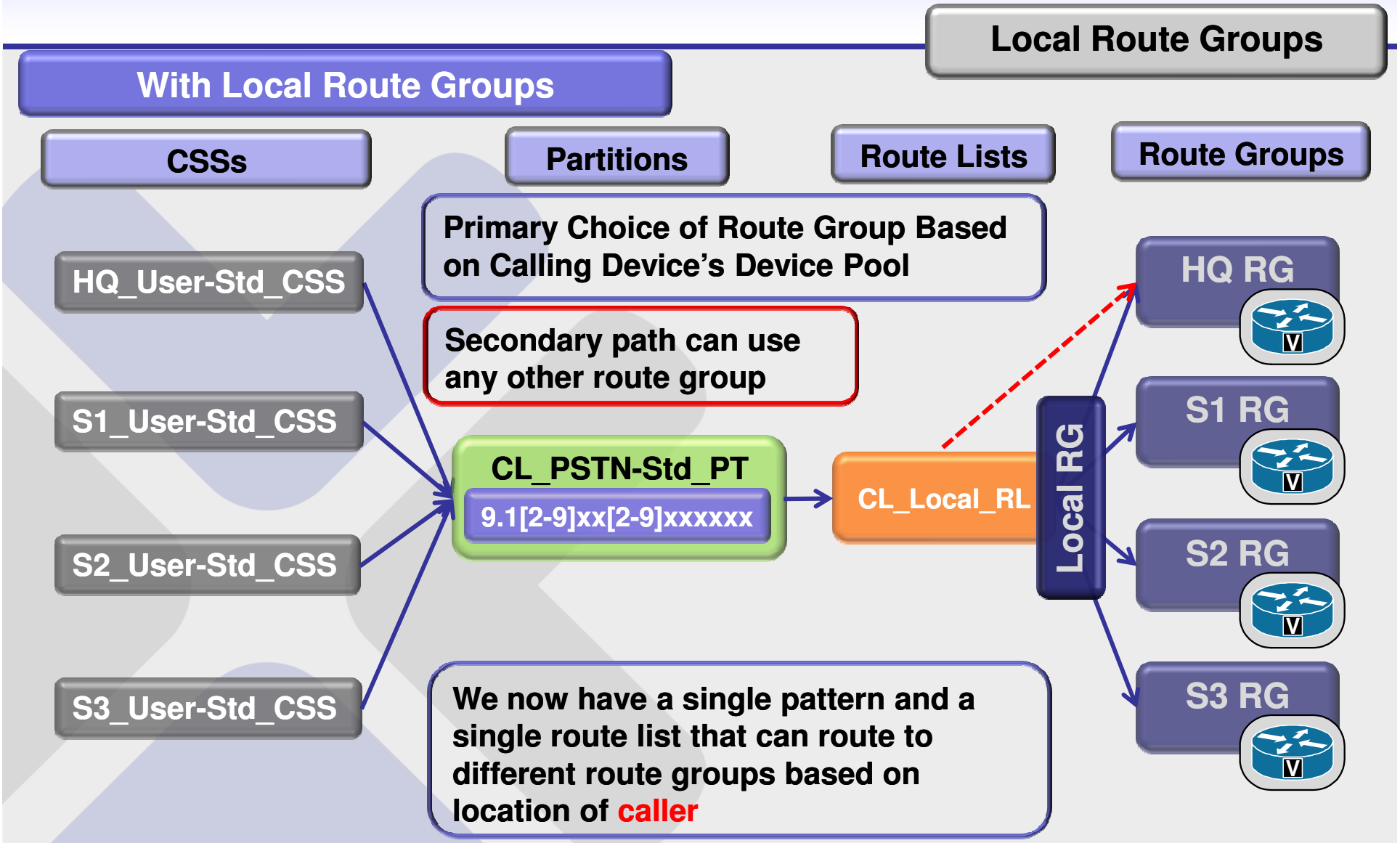
Copyright 2009

Dial Plan and CUCM 7x



Copyright 2009

Dial Plan and CUCM 7x



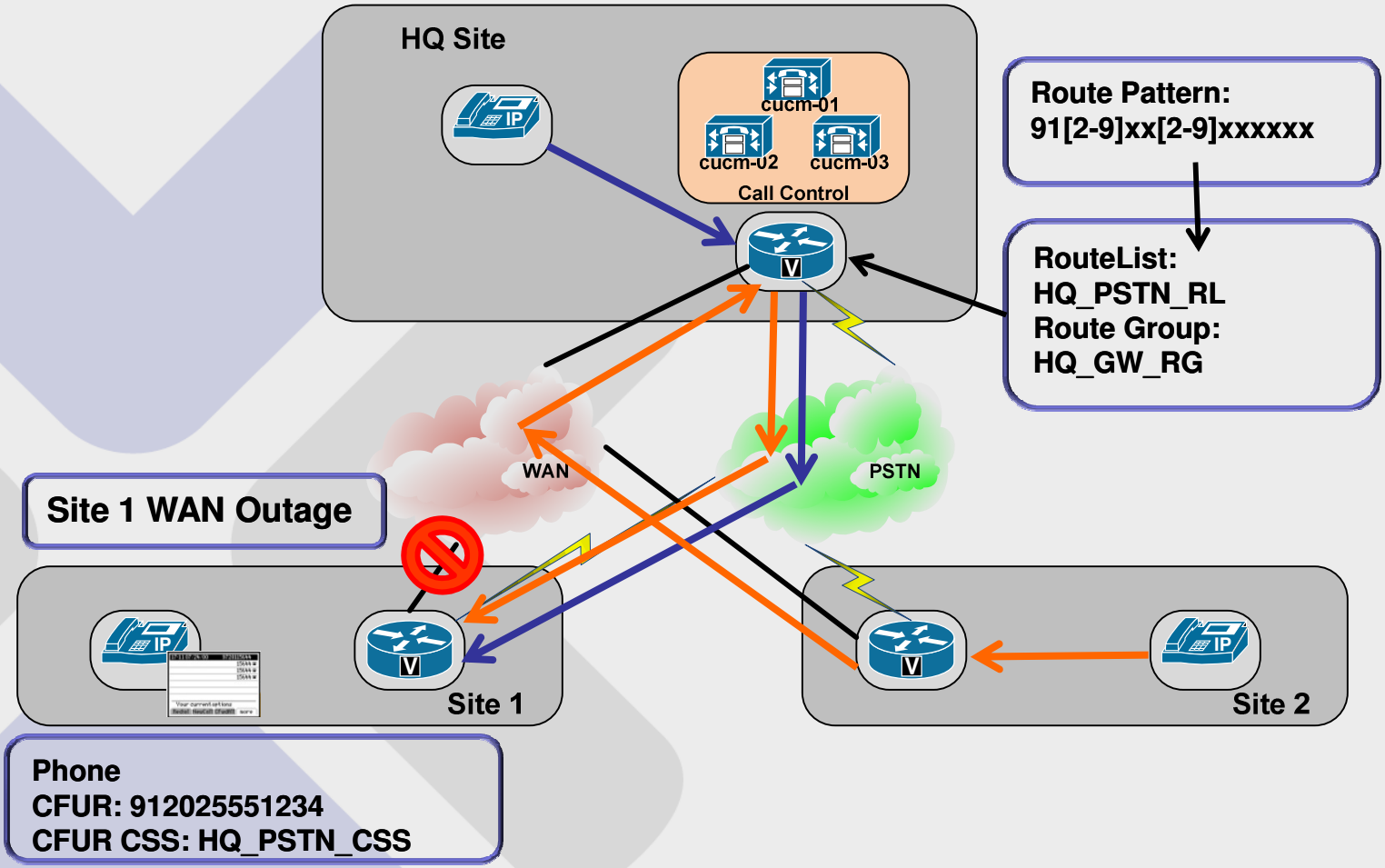
Copyright 2009

Dial Plan and CUCM 7x

Local Route Groups

Example: CFUR

Without Local RG

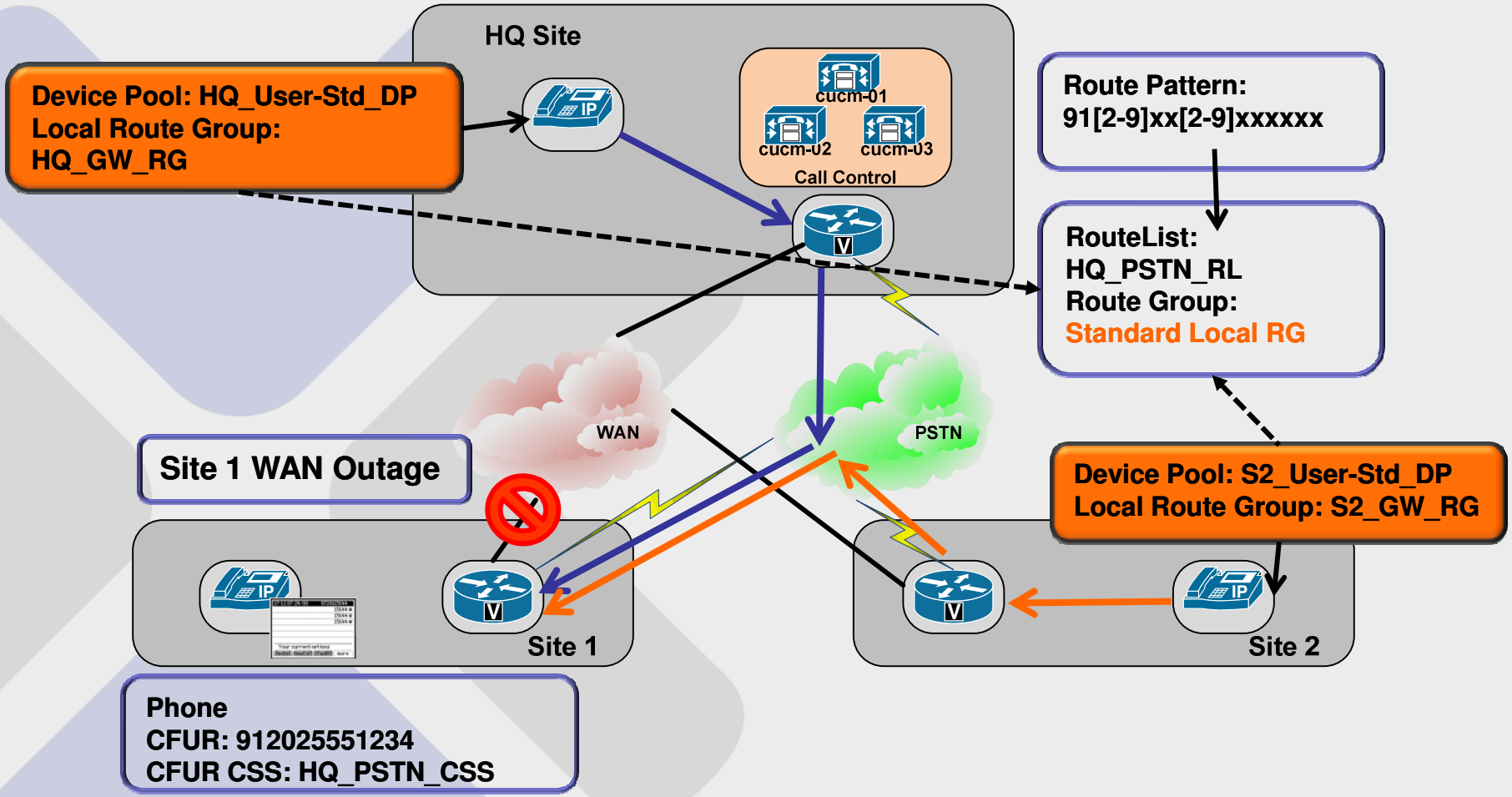


Copyright 2009

Dial Plan and CUCM 7x

Local Route Groups

Example: CFUR | With Local RG



Copyright 2009

Dial Plan and CUCM 7x

Local Route Groups

More Examples

Call Forwarding – In general	Any forwarding that allows off net dialing can take advantage of local route groups
CER Failure Scenario	Primary and Secondary CER server offline - Without LRG: you can only have one destination → one path (i.e. one PSAP) - With LRG: you can have one destination → site-specific path*
Tail End Hop Off (TEHO) with Local Site Failover	This is possible with or without LRG However, with LRG you can minimize the number or route patterns that are required

*Actually, in CM 4.1 there is a workaround available

Copyright 2009

Dial Plan and CUCM 7x

Globalized Format Dialing

ITU-T E.164 Recommendation

- Defines international public telecommunications numbering plan for PSTN (and other networks)
- Maximum 15 digits
- E.164 numbers start with a country code and no localized prefix
  - United States country code is “+1”
  - France country code is “+33”
- E.164 digits may be used in call setup if the ingress network/switch accepts the digit format
  - Localized international dialing prefixes still required for many places (e.g. 011 in North America)
  - Cisco Unified Communications Manager 7x accepts the E.164 format

Copyright 2009

Dial Plan and CUCM 7x

Globalized Format Dialing

The "+" Dialing Concept

- Users are not asked to enter "+" digit when dialing and most Cisco phones don't support "+" digit entry (7921 and 7925 do)
- Applications like "Click-to-Call" and CUCIMOC* or directories like Corporate Directory, speed dials, Missed Calls, etc. can use "+" dialing natively
- From an egress point of view:
  - "globalize" dialed digit strings *prior* to routing decision
  - On egress, localize the pattern to conform with PSTN
- From an ingress point of view:
  - "localize" ingress patterns *prior* to routing decision

*Cisco UC Integration for Microsoft Office Communicator

Copyright 2009

Dial Plan and CUCM 7x

Globalized Format Dialing

Transformation Patterns

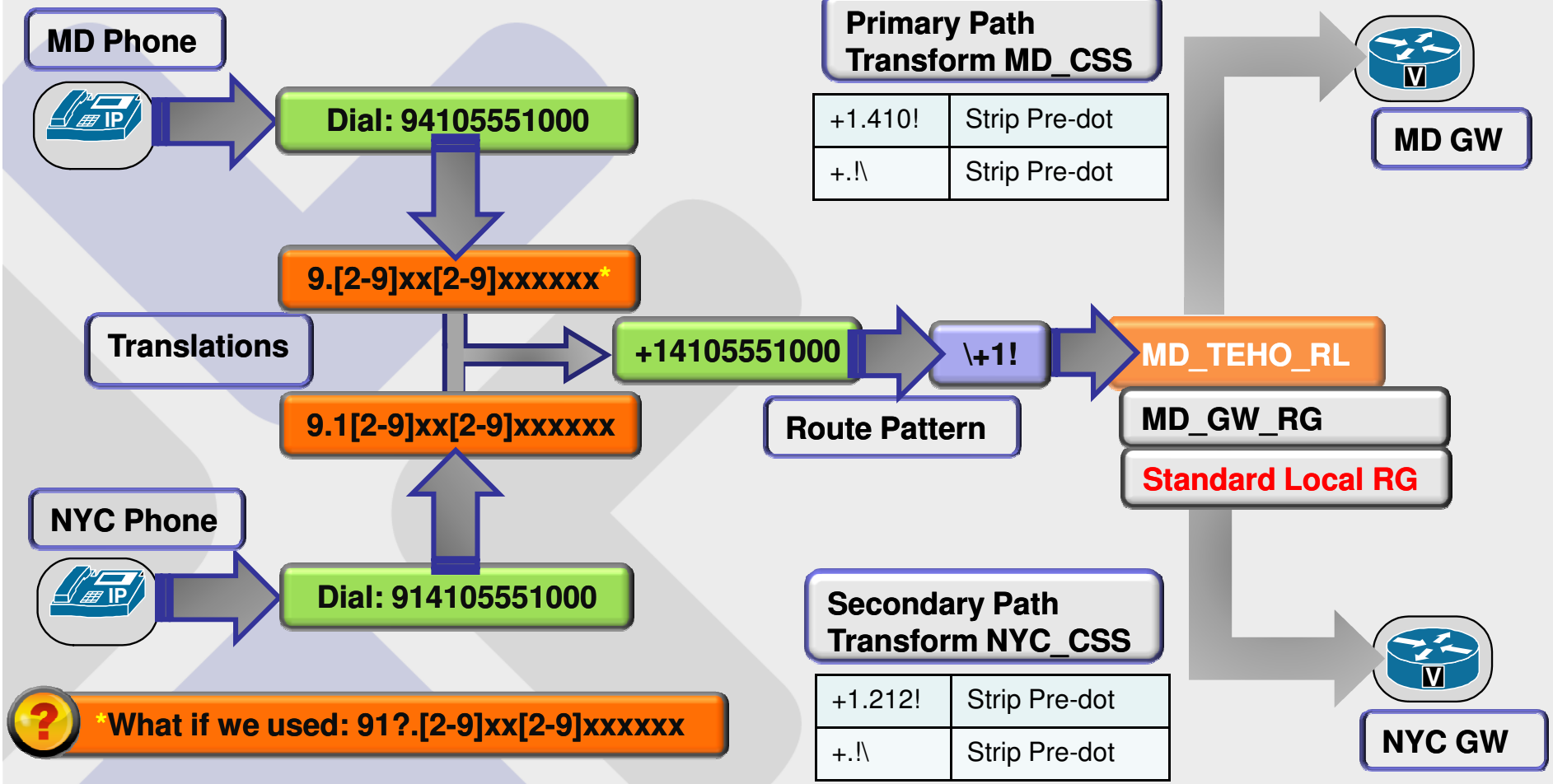
- Localized call routing prefixes for National, International, etc. are still required (i.e. no "+" dialing in ISDN Q.931 call setup)
- Calling number format presented on a phone are typically dictated by the end user
- Number format for calls presented to the gateway for routing off net are dictated by the gateway and network routing the call
- A mechanism is required to handle "transformation" of the E.164 "global" format to relevant localized patterns

Copyright 2009

Dial Plan and CUCM 7x

Globalized Format Dialing

An Example: Egress



Copyright 2009

Dial Plan and CUCM 7x

Globalized Format Dialing

An Example: Ingress

PSTN Caller

CLID: 2025551234

DC GW

Transform Calling Party Ingress

National	Prefix +1
International	Prefix +
Subscriber	Prefix +1202

DC Phone

Display	5551234
Call Back	+12025551234

CA Phone

Display	2025551234
Call Back	+12025551234

Germany Phone

Display	+12025551234
Call Back	+12025551234

DC Devices Transform -In CSS

+1202.!	Strip Pre-dot
+1.!\	Strip Pre-dot
+!	

Globalize on Ingress (GW) and Localize on Egress (Phone). The idea is the user gets the display they are used to and the ability to call back without "Edit Dial"

Copyright 2009

Dial Plan and CUCM 7x

Globalized Format Dialing

Possible Benefits

Emergency Calling	Corporate wide emergency number that routes to PSAP number that is localized to caller
Automated Alternate Routing (AAR)	- AAR calls placed to global numbers removes need for multiple AAR groups - Single pattern (\+.!) sufficient for all phones - Single AAR CSS for all phones
Tail End Hop Off (TEHO) with Local Site Failover	- Even more powerful than LRG alone - Can leverage \+ dialing and transformations to minimize number of route patterns required

Copyright 2009

Thank you for your time!

Q&A

NetCraftsmen UC Blog:

http://www.netcraftsmen.net/resources/blogs

Copyright 2009