

# **E.164: NUMBERING AND DIAL PLAN CONSIDERATIONS**

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# OVERVIEW

- ▶ Numbering and Dial Plans enable the enterprise to identify and connect users and applications to support business initiatives
- ▶ While Number Plans used for routing are transparent to end users, Dial Plans are not
- ▶ Changes to an existing enterprise numbering and dial plan are disruptive
  - End users are resistant to change
  - End users equate simplicity with length of digits that need to be dialed
  - End user demands are in many cases counter to what is required in the enterprise for a successful numbering and dial plan implementation
- ▶ Decisions regarding numbering and dial plans must be based on:
  - Scalability
  - Simplicity (based on understandable rules rather than length of digits dialed alone)
  - Maintainability

## E.164 NUMBERING AND DIAL PLAN BENEFITS

- ▶ Consolidation in the Enterprise is the major reason for moving to a highly scalable Numbering and Dial Plan
  - Growth
  - Acquisitions
- ▶ E.164 is highly scalable and can support growth and acquisitions globally without concern for dial plan conflicts
- ▶ Many customers deploy E.164 dial plans with instruction to end users to “dial from the office” the same way you “dial from home”
  - Intuitive
  - Simple, understandable
  - In this case it does require knowledge of local dial plans for mobile users; dial plan changes as you move from country to country

# PRIVATE NUMBERING AND DIAL PLAN BENEFITS

- ▶ Private number and dial plans are also highly scalable and can support growth and acquisitions globally without concern for dial plan conflicts
- ▶ Main advantages of private numbering plan
  - shorter number of digits to dial
  - dialing doesn't change as you move from location to location since the private numbering plan is the same throughout the enterprise

# DIFFERENCE BETWEEN NUMBERING AND DIAL PLANS

- ▶ Implementation of scalable enterprise wide numbering and dial plans is a prerequisite to supporting application call flows
- ▶ Numbering Plan describes the overall numbering scheme used by the enterprise
  - Public Numbering Plan (E.164) and/or
  - Private Numbering Plan
- ▶ Dial Plan specifies the actual digits dialed by users within the constraints of a defined Numbering Plan.
  - Digits dialed are used to make routing decisions
  - For simplicity must be based on understandable rules with few if any exceptions
  - Must have executive level sponsors in the enterprise and not left up to the telecommunications department for design and implementation

# NUMBERING PLAN

- ▶ Numbering plans address the specific **format of digits** to guarantee uniqueness with respect to accessing subscribers.
- ▶ Numbering Plans are used for **analysis and routing**
- ▶ In addition, numbering plans address ambiguity. A properly designed numbering plan will implement a format that will eliminate or minimize ambiguity when using a local dial plan.
  - For example, the subscriber number part of the E.164 numbering plan is built to identify local numbers.
  - That part of the number typically will not begin with the first digit of the national or international prefix specified in the DIAL PLAN.
  - Because of that, when a user dials a subscriber number it is non-ambiguous and can be routed with no inter-digit timeouts.



# NUMBERING PLAN (E.164)

- ▶ A **numbering plan** is a type of numbering scheme used in telecommunications. This is a set of rules used for making numbers. Most telephone numbers belong to the E.164 numbering plan
- ▶ **E.164** is an ITU-T recommendation which defines the international public telecommunication numbering plan used in the PSTN and some other data networks. It also defines the format of telephone numbers. E.164 numbers can have a maximum of 15 digits
- ▶ A **telephone numbering plan** is a plan for allocating telephone number ranges to countries, regions, areas and exchanges and to non-fixed telephone networks such as mobile phone networks.

## E.164 CANONICAL TELEPHONE NUMBER

- ▶ Canonical (unique) address format for phone numbers is a universal format recognized by systems such as Windows, Aura Messaging, Communication Manger, Session Manager, AES, LDAP Directories, Breeze™
- ▶ The E.164 format is:

Country Code	National Destination Code (optional)	Subscriber Number
	National (significant) number	
cc=1–3 digits	maximum 15-cc digits	
International public telecommunication number for geographic areas (maximum 15 digits)		

- E.164 numbers are preceded with a “+” plus sign to indicate that what follows is a country code and national number
  - Country/Region Code - The standard country/region code that identifies the country or region for a phone number.
  - National Destination Code (Area Code) - The area or city code for the phone number
  - Subscriber Number - The number for a phone subscriber.
- ▶ For example, in the US:
    - 1 is the country code, area code is three digits in length, subscriber number is 7 digits
    - +1 (425) 555-0100 (Windows) or +14255550100

# ADOPTION OF E.164 NUMBERING PLAN

- ▶ Global companies utilizing Session Manager typically implement E.164 numbering plan for routing of public numbers
- ▶ However, adoption of dial plan based on E.164 Numbering Plan varies based on regions of the world
  - North America has a relatively simple numbering plan that lends itself to dial plans based on it
  - The rest of the world typically have more complex numbering plan formats that make dialing based on E.164 numbers more difficult
    - Variable length area code and subscriber numbers
    - Up to 15 digits in length

# PRIVATE AND PUBLIC NUMBERING PLANS

- ▶ The consensus Public Dial Plan is governed by the ITU E.164 recommendation.
- ▶ Private numbering plans are typically developed by enterprise and governmental agencies for dialing shorter numbers than public numbers in the enterprise
- ▶ On-net dialing is typically comprised of a 7-digit number format where:
  - First 3 digits are used to identify a location
  - Last 4 digits used to identify the user
- ▶ The last 4 digits of the user's private number should coincide with the last 4 digits of their public number

# PUBLIC DIAL PLANS

- ▶ A Dial Plan specifies the actual digits dialed within the constraints of a defined Numbering Plan.
- ▶ **Dial Plan** describes how the **Numbering Plan** is executed. Dial plan execution includes dialing of **prefixes** to minimize ambiguity. Prefixes are a key part of the dial plan.
- ▶ A typical public dialed telephone number is comprised of digits that need not always be dialed (codes) and digits that must always be dialed (local number). The structure is:
  - Access code (either international or national) - only dialed for international and "national" (non-local domestic) calls.
  - Country code - only dialed from phones in other countries.
    - In North America, the country code digit "1" is also used as a 10-digit pre-indicator.
    - When dialed, it means that a 10-digit number will follow.
  - Area code – can be dialed from inside or outside the code area.
  - Local number - must always be dialed in its entirety.

# DIAL PLAN (CONTINUED)

- ▶ Within a Numbering Plan Area, Dial Plan implementation is **geographically specific**.
  - Overlay area codes
    - No subscriber number dialing
    - 10 or 11-digit dialing in North America
  - Adjacent area codes with local dialing between area codes
  - Adjacent area codes with long distance dialing between area codes
- ▶ Number dialed must be unique and routable

# GEOGRAPHICAL DIAL PLANS

- ▶ North America “Dial Plan Option 1”
  - International Prefix is “011” followed by country code and national number
  - National Prefix is “1” followed by national number
    - North America is unique in that the National Prefix coincides with the Country Code “1”
- ▶ Predominant Dial Plan outside of North America “Dial Plan Option 0”
  - International Prefix is “00” followed by country code and national number
  - National Prefix is “0” followed by national number

# DIAL PLAN OPTION 1: NORTH AMERICAN NUMBERING PLAN

- ▶ The North American Numbering Plan (NANP) is a system for three-digit area codes and seven-digit telephone numbers that direct telephone calls to particular regions on a public switched telephone network (PSTN), where they are further routed by the local network. It is applied to the United States and its territories; Canada; Bermuda; and many Caribbean nations.
- ▶ The NANP is administered by the *North American Numbering Plan Administration (NANPA)*.



# NANP FORMAT

- ▶ Current NANP number format can be summed up via the following:
  - NPX NXX XXXX where
    - NPX = [2-9][0-8][0-9]
    - NXX = [2-9][0-9][0-9]
    - XXXX = [0-9][0-9][0-9][0-9]
- ▶ Digit 1
  - Is Country Code as well as,
  - National Prefix Digit used to pre-indicate 10-digit number
- ▶ Service code format = X11

# DIAL PLAN 0 FORMAT

- ▶ Current Dial Plan number format can be summed up via the following:
  - International Prefix is 00
  - Country Code (variable length)
  - Digit 0 is used as National Number Prefix for calls within Country
  - National Number is comprised of
    - City/Area Code (variable length)
    - Subscriber Number (variable length)

# PBX ROUTING AND DIAL PLANS

- ▶ Dial Plan specifies the format of the digits that are dialed
- ▶ Dialed Digits may be adapted for analysis and routing
  - Uniform Dial Plan Table adapts dialed digits for AAR or ARS or extensions
  - AAR and ARS Digit Conversion adapts digits for AAR/ARS Analysis
  - AAR and ARS analysis tables analyze and route calls
- ▶ Routing is based on analysis of dialed digits
  - Automatic Route Selection is used to analyze digits dialed in accordance with public numbering plan
  - Automatic Alternate Routing (AAR) is used to analyze digits dialed in accordance with private numbering plan
- ▶ Route Pattern adapts numbers to the local PSTN Dial Plan or Private Network Dial Plan

# PBX DIAL PLAN

- ▶ Private Branch Exchange systems have historically developed Public and Private Dial Plans typically based on the following:
  - “9” feature code used to access public routing tables and provide least cost routing. Public routing tables reflect E.164 numbering plan
  - “8” feature code used to access private routing tables and reflects private numbering plan
  - 2-7 defined as extensions with maximum length 7-digits
  - 1 defined as feature codes
  - \* and # defined as additional feature access codes
  - 0 defined as operator

# UNIFORM DIAL PLAN

- ▶ Dial Plan based on dialing of extension number without use of public or private feature access codes.
- ▶ Based on Public or Private Numbering Plan
- ▶ A key feature of Uniform Dial Plan is that extension numbers are unique in the enterprise
- ▶ UDP based on private dial plan is typically 7 digits in length
- ▶ UDP based on public dial plan is typically
  - National number
  - Based on E.164 number (w/o the “+”)
- ▶ Communication Manager UDP can support dialing of up to 18 digits

# MULTI-LOCATION DIAL PLAN (DIAL PLAN 1)

- ▶ CM has a feature that allows short code dialing within a location
- ▶ This feature is important in the case of a dial plan based on E.164 Number Plan with long extension numbers
  - Within a location a user can dial a short code
    - In North America this is typically 7 digits in length starting with the digits 2-9 (subscriber number)
    - Does not overlap with extensions that begins with the digit 1
    - In this case dialing within a location with short codes does not result in short inter-digit timeouts
    - Once number is dialed CM inserts the digit 1 and proper area code to build the short number to an 11-digit extension number for routing
  - Between locations must still dial the full E.164 based 11-digit number

# MULTI-LOCATION DIAL PLAN (DIAL PLAN 0)

- ▶ This feature is particularly important in “dial plan” counties based on E.164 Number Plan with long extension numbers
  - Within a location a user can dial a short code
    - Typically the subscriber number
    - Does not overlap with extensions that begins with the digit 1
    - In this case dialing within a location with short codes does not result in short inter-digit timeouts
    - Once number is dialed CM inserts the country code and proper area code to build the short number to an E.164 based extension number for routing
  - Between locations
    - Within the same country dial “0” plus the national number
    - Between countries dial “00” plus county code and national number

# NON-DID NUMBERS

- ▶ Most customers will have non DID numbers as well
- ▶ Can still be based on E.164 using numbers not defined by the National Numbering Plan
- ▶ In North America can have non DID number with
  - 9 as the second digit of the area code (these area codes are reserved and not used in public arena
    - 1995-222-1234
  - Or Subscriber part of the number start with 10 or 11
    - 1303-101-1234
    - In this case short code dialing can be accommodated since 10 does not conflict with the E.164 number that start with 12 through 19
- ▶ Outside of North America similar techniques can be used based on the unique dial plan of a particular country



# MIGRATING TO PRIVATE OR PUBLIC DIAL PLAN

- ▶ The following must be addressed prior to implementing enterprise wide numbering and dial plan:
  - The Numbering Plan(s) used by SM to analyze and route calls
    - Private Numbering Plan
    - Public Numbering Plan- E.164 or National
  - Dial plan(s) implemented in the associated CM
  - SIP handles administered in SM to support registrar function for SIP telephones
  - Extension numbers implemented in CM based on dial plan
- ▶ See following White Paper for more details  
<https://downloads.avaya.com/css/P8/documents/100182873>

# SESSION MANAGER (SM)

Avaya Session Manager performs two major functions:

- ▶ Routing for calls to non-SIP users using Network Routing Policies (NRP) for
  - All outbound PSTN calls (off-net)
  - All inbound PSTN calls to
    - non-SIP users
    - VDNs and vectors
  - Named applications
    - Meeting Exchange,
    - Avaya Experience Portal,
    - Avaya Aura Messaging
  - All private network calls (on-net calls)
- ▶ Sequencing
  - Explicit Sequencing to CM for SIP Users (SM as a Registrar)
  - Implicit Sequencing to utilize Breeze™ for SIP and non-SIP users

# SM AS CENTRALIZED ROUTER

- ▶ SM uses a numbering plan to centralize routing of calls to non-SIP users by administering SM Network Routing Policy (NRP) “routing applications” that include: Domains, Locations, Adaptations, SIP Entities, Entity Links, Routing Policies, and Dial Patterns.
- ▶ The Dial Patterns application, in particular defines the enterprise numbering plan (Note: “Number Patterns” would be a more precise description of the “Dial Patterns” application since the numbers administered in many cases are not actually dialed). Dial plans are local and contained within CM.

# SM CALL PROCESSING

- ▶ For explicit sequencing when SM receives an INVITE from it looks for a match with a SIP handle administered in SM. If there is a match, SM sequences the subsequent Subscribe and Invite messages to the associated CM.
- ▶ For implicit sequencing when Session Manager receives a SIP Invite message to or from a SIP or non-SIP
  - it first looks for a match with an implicit dial string administered in SM for origination or termination sequencing.
  - If there is no match SM then looks for matches in NRP dial patterns.
- ▶ Because of the links between SIP handles used for application sequencing to SIP users and dial patterns used by NRP to route calls to non SIP users must be coordinated for proper routing of calls between the two elements.

# DIAL PLANS AND SIP PHONES

- ▶ For SIP phones with Advanced SIP Telephony (AST) capabilities, the following procedure is used to communicate dial plan information to the phone:
  - Dial Plan information in CM is synchronized with SM and stored in the Personal Profile Manager (PPM) database for every SIP user.
  - Dial plan formats are then passed to SIP phones upon request using PPM when the phones initially register to SM and subscribe to CM, or when this information is pushed to the phones using System Manager.
  - SIP phones use this information to determine what the AAR and ARS feature codes are, when to apply dial tone, and when to send digits to SM for feature processing by CM-ES when the user dials a number from the SIP phone keypad

# CM AS A SEQUENCED APPLICATION

- ▶ Once the phone has a dial string that matches the dial plan in the phone, it sends the digits to SM in a SIP INVITE message.
  - SM looks up the user profile of the originating SIP telephone and forwards the call to the associated CM specified in the origination application sequence.
  - On the termination side SM looks up the user profile of the terminating SIP telephone and forwards the call to the associated CM specified in the termination application sequence

# SIP USER HANDLES: FORMAT

- ▶ A decision needs to be made regarding the format of SIP handles.
- ▶ The SIP handle(s) must be unique in the enterprise and based on the enterprise numbering plan
- ▶ Decisions regarding choice of SIP handle format are closely aligned with the numbering plan
  - If E.164 numbering format is chosen for enterprise routing, then the SIP handle should be E.164 or based on E.164
  - If enterprise canonical format is chosen, then the SIP handle should be enterprise canonical as well. There are cases where both number formats are used for routing in the enterprise

# SIP USER HANDLES: ADMINISTRATION

- ▶ SIP handles are administered in System Manager and are used for:
  - login to SIP telephones by SIP users, registration to SM, subscription to CM and subsequent sequencing of SIP user calls. The handles discussed in this document are numeric followed by a domain.
- ▶ The SIP user logs into the SIP telephone by dialing the numeric part of a user handle.
- ▶ When using E.164 numbering plan for routing, two SIP handles need to be administered:
  - a SIP handle in E.164 format with the leading + sign to interface with SM NRP and
  - another handle without the + sign used by SIP users to log in and register to SM and subscribe to CM-ES and CM-FS and subsequent call sequencing.



# CM EXTENSIONS (1)

- ▶ CM extensions should match or be a subset of the SIP handle.
  - In CM, there is a direct mapping between the the SIP handle used to register the user and the extension number administered on the “off-pbx-telephone station-mapping”.
- ▶ CM extensions and short codes are administered as part of the dial plan.
  - Depending on the size of the CM system and the size and number of DID numbers used by this CM system, the length of the extension number can be quite short (3-digits for example) or can be relatively long based on E.164 number.
  - All extensions must be unique, within the CM system.
  - All short codes need to be unique within a location defined in the CM system (short codes are beyond the scope of this document).
  - Extension numbers do not need to be unique in the enterprise.

## CM EXTENSIONS (2)

- ▶ Consolidated CM systems that cover large geographic areas with large number of phones will typically have longer extension lengths than smaller standalone systems because of the need for uniqueness of extensions within the CM system.
  - These larger systems will typically have extension numbers that may be enterprise canonical as well and can be the SIP handle
  - This would be the case for extensions based on E.164 numbering format
- ▶ Extension numbers in smaller standalone systems are typically not enterprise canonical and will be a subset of the number used as the SIP handle

# SIP HANDLE AND EXTENSION OPTIONS

- ▶ Following are four different SIP handle and extension options that may be used in conjunction with an existing or proposed enterprise wide numbering and dial plan.
- ▶ These options are not exhaustive but do represent a sample of combinations handles and extensions that can be utilized.
- ▶ In many cases more than one of these options can be deployed in the same enterprise;
  - every one of these options has an E.164 handle
  - coordinated with Session Management Network Routing Policies (NRP) based, at least in part, on E.164 Numbering Plan.

# OPTION ONE: EXTENSION BASED ON E.164 NUMBERING PLAN W/O THE “+”

- ▶ This configuration can be used with consolidated CM system with many SIP endpoints
  - The handles used are E.164 with the + sign and another handle without the + sign.
  - In this case the handle used to login to the SIP phone is the same as the extension number. Following is an example based on North America:
- ▶ SIP Handles
  - +13035380000 (E.164)
  - 13035380000 (Public Long)
- ▶ Extension Number
  - 13035380000 (Public Long)
  - Short code within location 5380000

## **OPTION TWO: EXTENSION BASED ON PRIVATE LONG NUMBER**

- ▶ This is another typical configuration of a consolidated CM system with many SIP endpoints
  - The handles used are E.164 with the + sign and another handle that reflects enterprise canonical numbering plan.
  - In this case, again, the handle used to login to the SIP phone is the same as the extension number. Following is an example based on North America:
- ▶ SIP Handles
  - +13035381234 (E.164)
  - 3211234 (in this example, only the last four digits match the E.164 number-Private Long)
- ▶ Extension Number
  - 3211234 (Private Long)

# OPTION 3: EXTENSION BASED ON SUBSET OF E.164 NUMBERING PLAN

- ▶ This configuration is appropriate for CM system in which shorter length extension numbers are desirable
  - These extension numbers are unique within the CM system but not unique in the enterprise.
  - The extension length in this case is typically 4, 5 or 7-digits and reflects a subset of the E.164 based handle
  - The key here is that the extension number is a subset of the E.164 handle used to login into the SIP phone. Following is an example based on North America:
- ▶ SIP Handles
  - +13035381234(E.164)
  - 13035381234(Public Long)
- ▶ Extension Number
  - 81234 (Public Short)

# OPTION FOUR: EXTENSION BASED ON SUBSET OF PRIVATE NUMBERING PLAN

- ▶ This configuration can be used by a smaller CM system in which shorter length extension numbers are desirable.
  - Extension numbers are unique within the CM system but not unique in the enterprise.
  - The extension length in this case is typically 4 or 5-digits and reflects a subset of the enterprise canonical based handle which is typically 6 or 7 digits
  - The extension number is a subset of the enterprise canonical handle used to login into the SIP phone. Following is an example based on North America:
- ▶ SIP Handles
  - +13035381234 (E.164)
  - 3211234 (in this example, only the last four digits match the E.164 number-Private Long)
- ▶ Extension Number
  - 1234 (Private Short)

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# SUMMARY

- ▶ Decisions regarding Numbering and Dial Plans have major impact on an enterprises ability to support communications between users and applications
- ▶ Scalability and ease of use are primary concerns
- ▶ Migrations to a new public or private numbering and dial plan must be scalable, anyone that has experienced this does not want to repeat
- ▶ Migrations must be supported by executives in the enterprise or success will be limited