ITU Workshop on "Origin Identification and Alternative Calling Procedures"

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ENUM: an Enabler for VoIP and Next Generation Services

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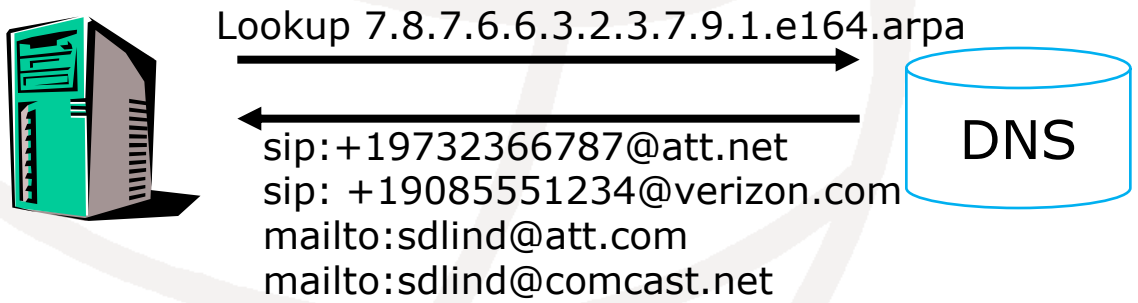
What is ENUM?

- Provides mapping from E.164 numbers to IP resources
  - Telephone number as domain name
  - Built on top of DNS
  - Number "holder" needs to opt-in
  - Example: +1-973-236-6787



Assumption

- Use of standard telephone numbers (ITU-T Recommendation E.164) is not going away
  - PSTN/analog terminals are going to be around
  - IP phones will use 12-button keypad
  - Globally unique identifier that has established familiarity with end users

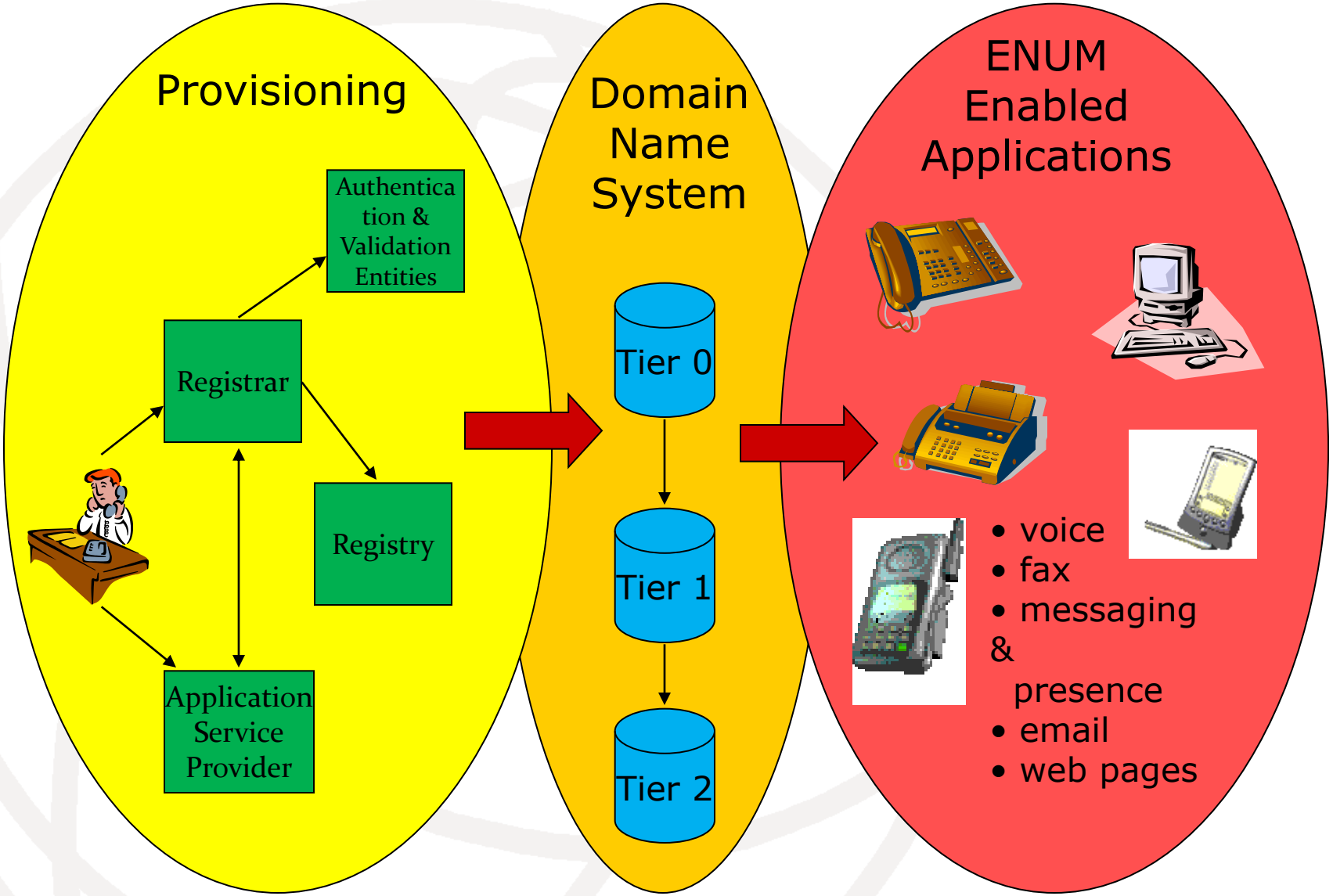
Types of ENUM

- End-User ENUM used to discover IP endpoints where data is placed in a public ENUM tree by end-users (or their agents)
- Provider ENUM (aka Carrier or Infrastructure ENUM) used to discover IP-based points of interconnection where data is placed in a private ENUM tree by carriers of record

Why is ENUM Important?

- ENUM will enable VoIP interoperability
  - E.164 addresses will be used as names in VoIP networks
  - ENUM enables call routing between VoIP service providers
  - E.164 addresses are not directly routable in an IP/VoIP network
  - Use ENUM to map E.164 number to an Internet address that can be used to setup communication (e.g. sip:19732366787@xyz.net)

Three Pieces of the ENUM Puzzle



How does ENUM Work?

- Step 1: Take an E.164 number and create a fully qualified domain name in a single highly defined and structured domain
  - +1-973-236-6787
  - 19732366787
  - 7.8.7.6.6.3.2.3.7.9.1.e164.arpa.

Step 1 - Explanation

- Each digit can become a definable and distributed “zone” in DNS terms
- Delegation can (doesn’t have to) happen at every digit, including at last digit
- Zones such as country codes, area codes or primary delegated blocks of numbers can be delegated as well as individual numbers

How does ENUM Work? (cont.)

- Step 2 – Look up FQDN in defined DNS Registry and retrieve NAPTR records

```
$ORIGIN 7.8.7.6.6.3.2.3.7.9.1.e164.arpa.
IN NAPTR 10 10 "U" "E2U+mailto"
    "!^.*$!mailto:spam@sdlind.com!"
IN NAPTR 20 10 "U" "E2U+ldap"
    "!^+1(.*)$!ldap://ldap.telco.us/cn=0\1"
```

[Note that no line break should be in the records]

History of ENUM: Part 1

- IETF developed original concept
  - RFC 3761 defines “protocol;” was updated from original RFC 2916 to reflect implementation experience
  - IAB recommends use of .arpa TLD for ENUM infrastructure
  - IETF sought input from ITU-T on delegation of Rec. E.164 country codes in DNS

IETF Working Groups & RFCs

ENUM – tElephone NUmber Mapping
Defined basic protocol and service types

- RFC 3761 The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application (ENUM)
- RFC 3764 enumservice registration for Session Initiation Protocol (SIP) Addresses-of-Record
- RFC 4114 E.164 Number Mapping for the Extensible Provisioning Protocol (EPP)
- RFC 4769 IANA Registration for an Enumservice Containing Public Switched Telephone Network (PSTN) Signaling Information
- RFC 5067 Infrastructure ENUM Requirements
- RFC 5526 The E.164 to Uniform Resource Identifiers (URI) Dynamic Delegation Discovery System (DDDS) Application for Infrastructure ENUM

IETF DDDS RFCs

ENUM is an application of the Dynamic Delegation Discovery System (DDDS):

- RFC 3401
  Dynamic Delegation Discovery System (DDDS) Part One:
  The Comprehensive DDDS
- RFC 3402
  Dynamic Delegation Discovery System (DDDS) Part Two:
  The Algorithm
- RFC 3403
  Dynamic Delegation Discovery System (DDDS) Part Three:
  The Domain Name System (DNS) Database
- RFC 3404
  Dynamic Delegation Discovery System (DDDS) Part Four:
  The Uniform Resource Identifiers (URI)

IETF Working Groups & RFCs

- DRINKS
  - (Data for Reachability of Inter/tra-NetworK SIP)

http://datatracker.ietf.org/wg/drinks/charter/

  - Developing enhanced provisioning protocols for ENUM-like registries

- SPEERMINT
  - (Session PEERing for Multimedia INTerconnect)

http://datatracker.ietf.org/wg/speermint/charter/

  - SPEERMINT focuses on architectures to identify, signal, and route delay-sensitive (real-time) communication sessions. These sessions use the SIP signaling protocol to enable peering between two or more administrative domains over IP networks.

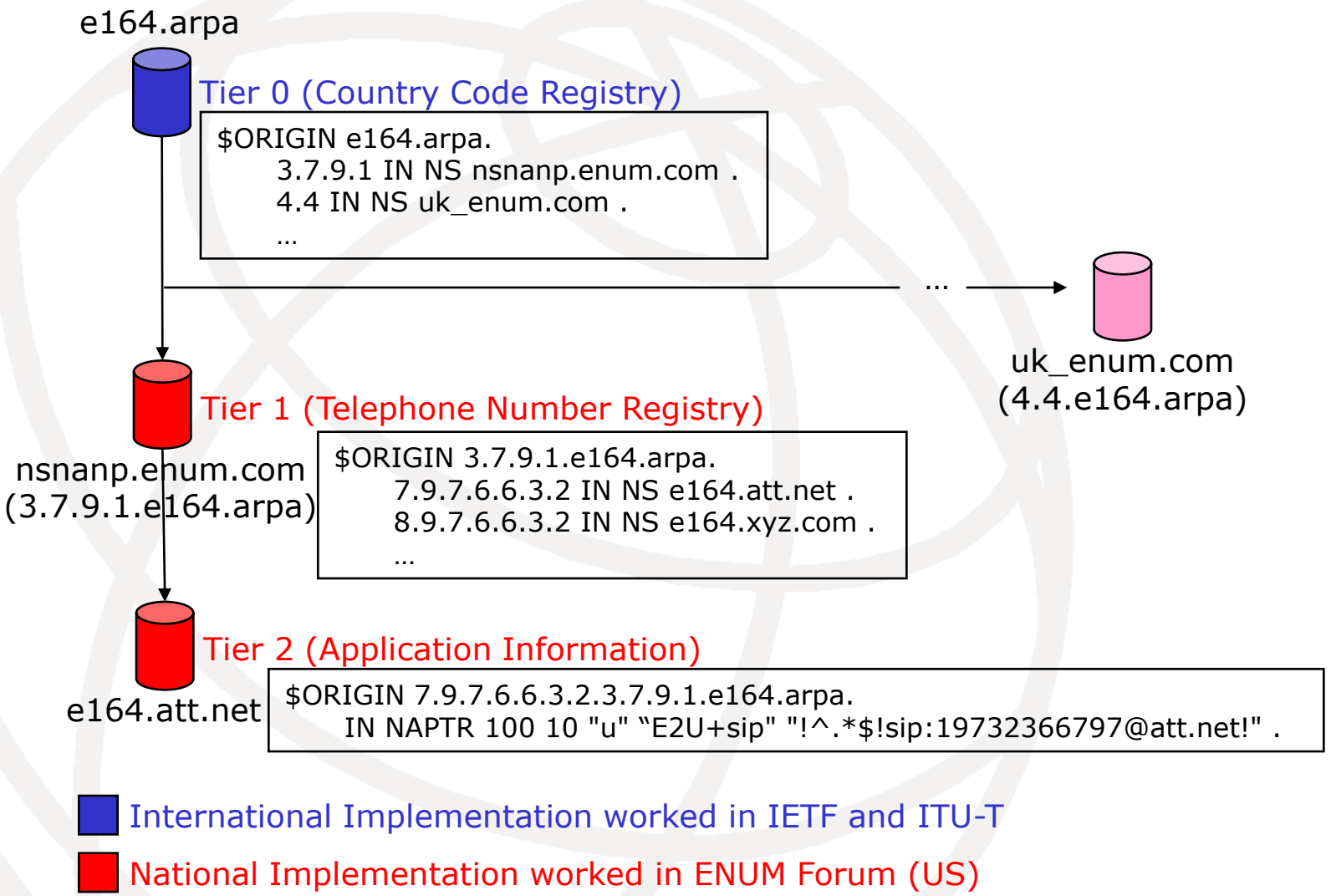
History of ENUM: Part 2

- ITU has developed procedures for the delegation of country codes
  - Preservation of national sovereignty a key issue with ITU Member States
  - Interim procedures in place for delegation of geographic country codes and shared network codes into e164.arpa
  - Final procedures waiting for consensus on use of .arpa as proper TLD

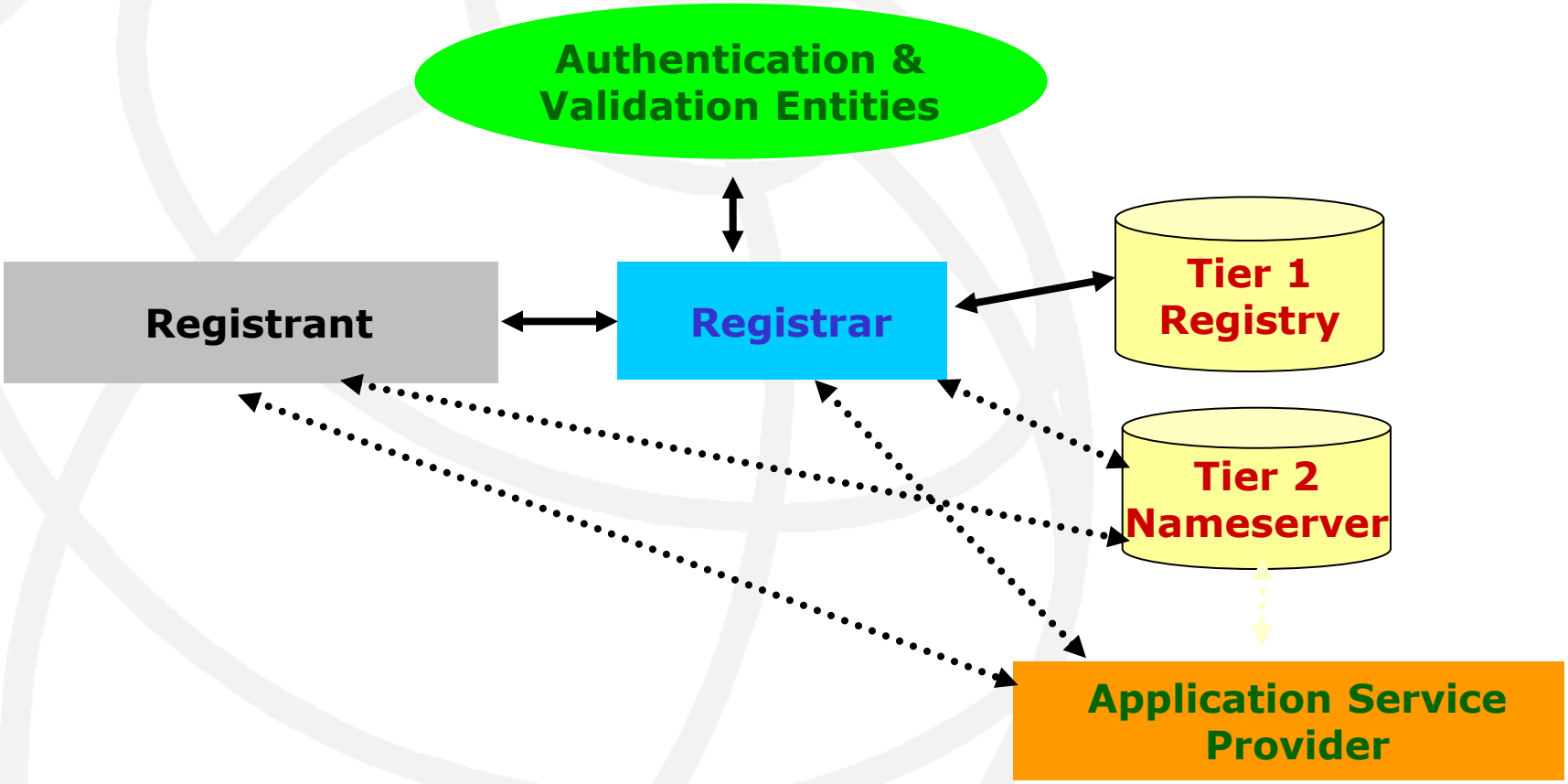
Current List of CC Delegations

- ITU ENUM information available at:
  - http://www.itu.int/en/ITU-T/inr/enum/Pages/default.aspx

The Public ENUM Infrastructure



Provisioning



Provider ENUM

- Also known as Carrier or Infrastructure ENUM
- Supports IP interconnection among Service Providers
- Provides routing information to call originating service providers without exposing private end-user or terminating service provider information

Definitions

- Provider ENUM - the use of the technology in IETF RFCs by a carrier-of-record for a specific E.164 number to map a telephone number into a URI that identifies a specific point of interconnection to that carrier's network that could enable an originating carrier to establish an IP-based connection
- Carrier (Service Provider) of Record - an entity that is officially assigned E.164 numbers by the NRA or through porting or pooling (matters controlled by national authorities)
- Federation – a group of Service Providers who, together build, operate and maintain an ENUM Registry

Provider ENUM Approach

- End-User ENUM was approached from top-down
  - Five years of active debate (2001-2006) in SG2 has not resulted in consensus
  - While there have been plenty of trials, the few commercial implementations have had lackluster results
- In order to avoid similar problems and delays, approach for Provider ENUM has been bottom-up

ENUM Development in North America

- Try It
  - Develop Specifications
  - Conduct Trials
- Build It
  - RFP for Tier 0/1
  - Selected vendor for development and operation
- Globalize It

US Trials

- End-user trial with 15 companies
  - Conducted 3/2006 – 6/2007
  - Concluded that even though ENUM works from a technology standpoint, there remains business and market issues that make implementation premature
- Provider ENUM concept trial in 2007
  - Focus on provisioning and validation

U.S. ENUM ad hoc

- Convened in 2001 after an NTIA discussion in December, 2000
- Developed U.S. positions on ITU-T ENUM activities
- Produced a report back to the Department of Commerce and NTIA
- Recommended convening of a new organization: the ENUM Forum

ENUM Forum

- An informal group of interested participants from the Internet and telecommunications industries
- Divided into a series of task groups
  - Architecture/infrastructure
  - Provisioning
  - Applications
  - Security/privacy
  - Interworking
  - Legal
- Published "Specifications for United States Implementation of ENUM" in February 2003

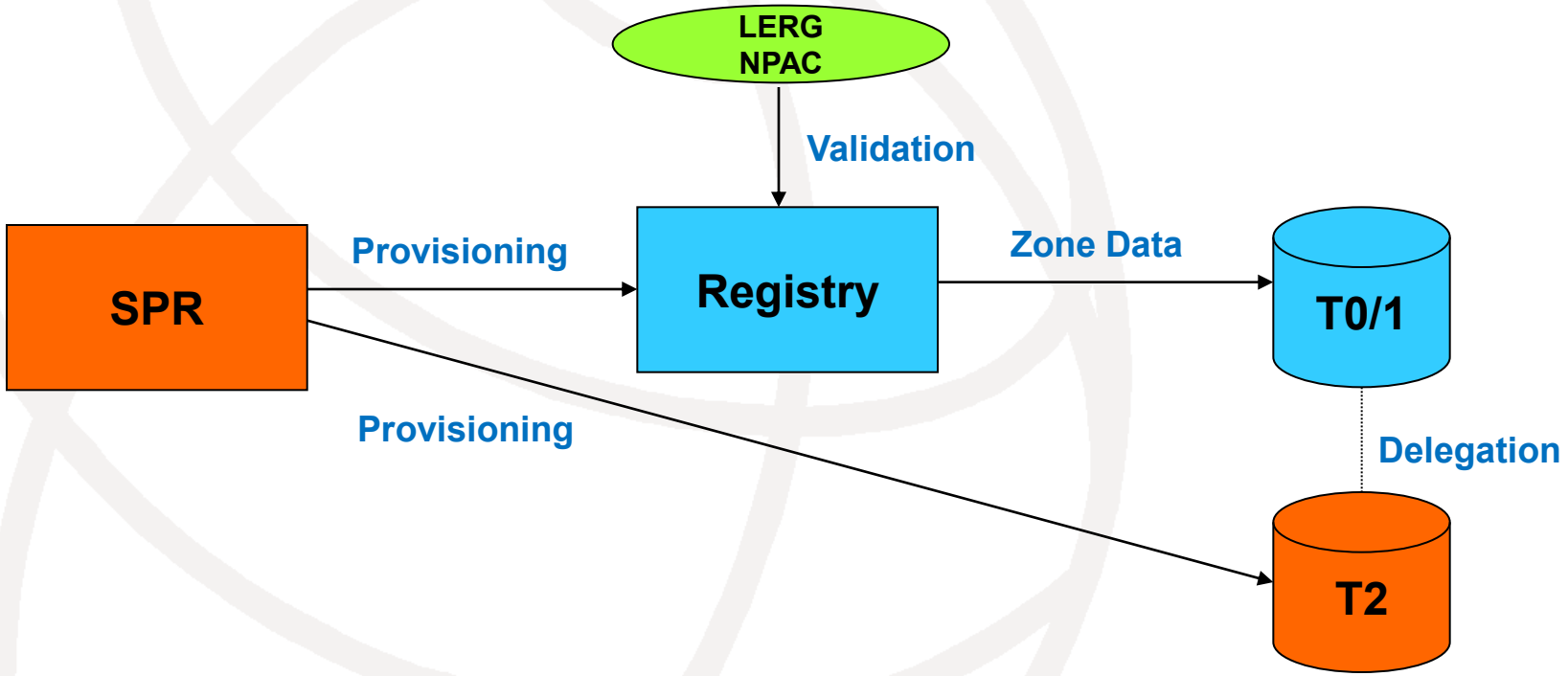
ENUM Forum

- No consensus on specific implementation details necessary to support development
- Agreed that a smaller, more focused organization was needed to refine the specifications and conduct a U.S. trial
- A group of interested parties met to plan the formation of an LLC for North American ENUM

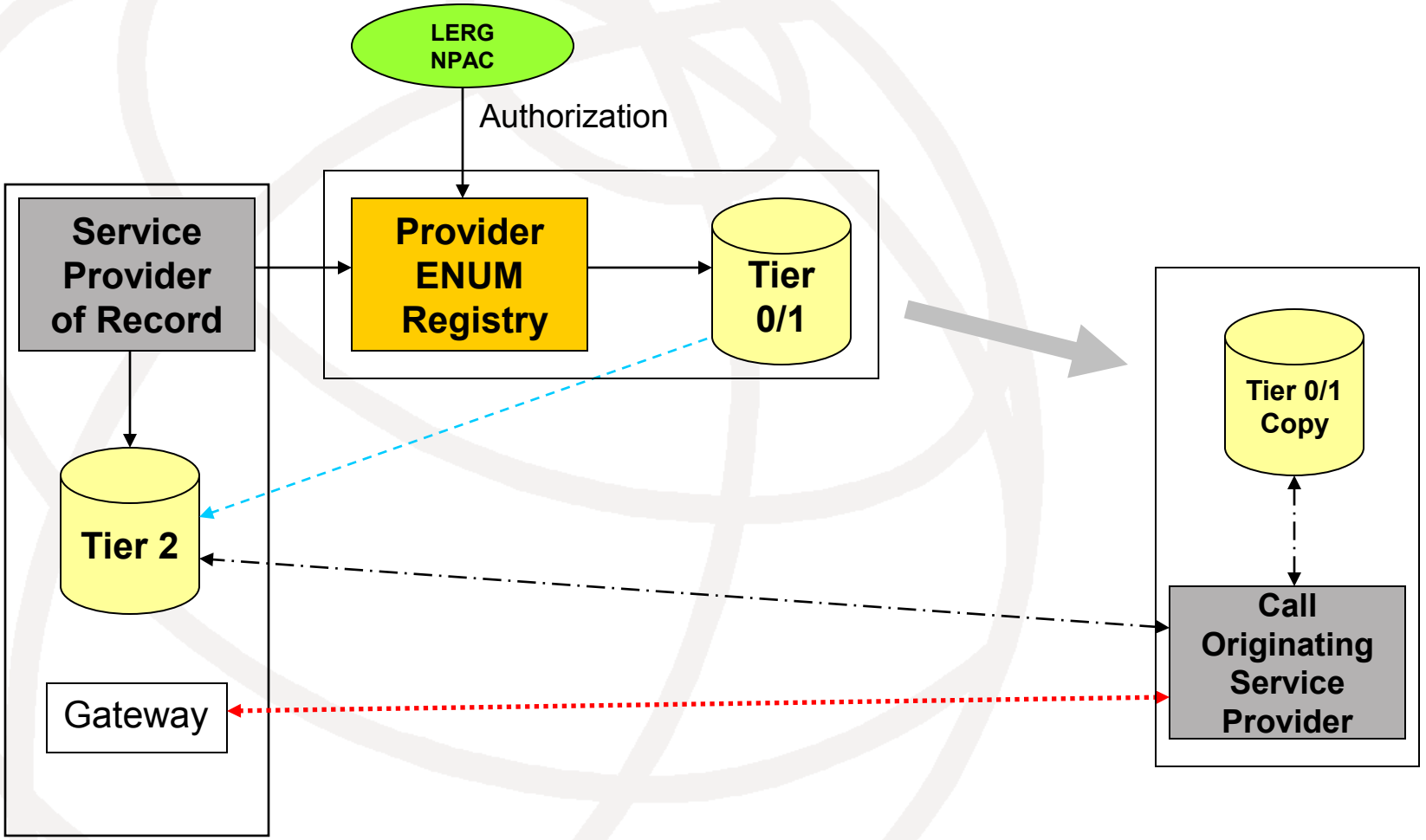
CC1 ENUM LLC

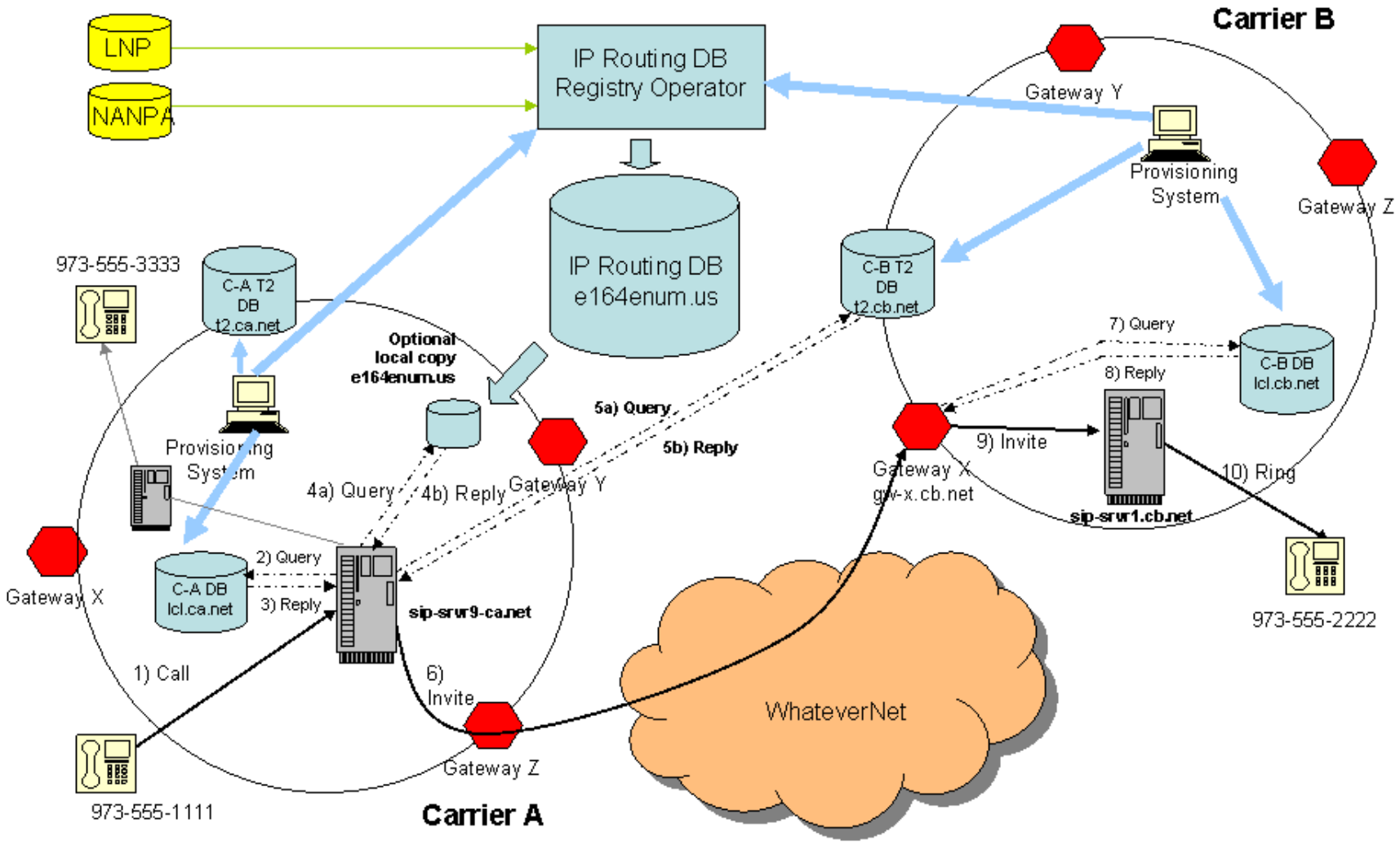
- Major telecom service providers and a major Internet domain Registrar formed the Country Code 1 ENUM LLC in 2004
- The LLC set up an open Technical Advisory Committee that refined the ENUM Registry specifications developed by the ENUM Forum

Provider ENUM Registry Architecture



Provider ENUM




LNP
NANPA
IP Routing DB
Registry Operator
IP Routing DB
e164enum.us
Carrier B
Gateway Y
Provisioning
System
Gateway Z
C-B T2
DB
t2.cb.net
7) Query
C-B DB
lcl.cb.net
8) Reply
9) Invite
10) Ring
Gateway X
gw-x.cb.net
sip-srvr1.cb.net
973-555-2222
973-555-3333
C-A T2
DB
t2.ca.net
Optional
local copy
e164enum.us
5a) Query
5b) Reply
Provisioning
System
4a) Query
4b) Reply
Gateway Y
Gateway X
C-A DB
lcl.ca.net
2) Query
3) Reply
sip-srvr9-ca.net
1) Call
6)
Invite
WhateverNet
Gateway Z
973-555-1111
Carrier A

Call Flow Details

1. Caller Dials 555-2222; sip server converts to full E.164 number
2. Query 2.2.2.2.5.5.5.3.7.9.1.lcl.ca.net
3. Reply: NXDOMAIN
4a/5a. Query 2.2.2.2.5.5.5.3.7.9.1.e164enum.us
4b. Reply w/ NS t2.cb.net
5b. Reply w/ NAPTR sip:+19735552222@gw-x.cb.net
6. Invite to sip:+19735552222@gw-x.cb.net
7. GW queries 2.2.2.2.5.5.5.3.7.9.1.lcl.cb.net
8. Reply w/ NAPTR sip:+19735552222@sip-srvr1.cb.net
9. Invite to +19735552222@sip-srvr1.cb.net

Illustrative contents of name servers

IP Routing DB:

$ORIGIN e164enum.us

1.1.1.1.5.5.5.3.7.9.1 IN NS t2.ca.net

2.2.2.2.5.5.5.3.7.9.1 IN NS t2.cb.net

3.3.3.3.5.5.5.3.7.9.1 IN NS t2.ca.net

Carrier-A Tier 2 DB:

$ORIGIN 1.1.1.1.5.5.5.3.7.9.1.e164enum.us

IN NAPTR 100 10 "u" "E2U+sip" "!^.*$!sip:+19735551111@gw-z.ca.net!"

$ORIGIN 3.3.3.3.5.5.5.3.7.9.1.e164enum.us

IN NAPTR 100 10 "u" "E2U+sip" "!^.*$!sip:+19735553333@gw-x.ca.net!"

Carrier-A Internal Routing DB:

$ORIGIN 1.1.1.1.5.5.5.3.7.9.1.lcl.ca.net

IN NAPTR 100 10 "u" "E2U+sip" "!^.*$!sip:+19735551111@sip-srvr9.ca.net!"

$ORIGIN 3.3.3.3.5.5.5.3.7.9.1.lcl.ca.net

IN NAPTR 100 10 "u" "E2U+sip" "!^.*$!sip:+19735553333@sip-srvr8.ca.net!"

Carrier-B Tier 2 DB:

$ORIGIN 2.2.2.2.5.5.5.3.7.9.1.e164enum.us

IN NAPTR 100 10 "u" "E2U+sip" "!^.*$!sip:+19735552222@gw-x.cb.net!"

Carrier-B Internal Routing DB:

$ORIGIN 2.2.2.2.5.5.5.3.7.9.1.lcl.cb.net

IN NAPTR 100 10 "u" "E2U+sip" "!^.*$!sip:+19735552222@sip-srvr1.cb.net!"

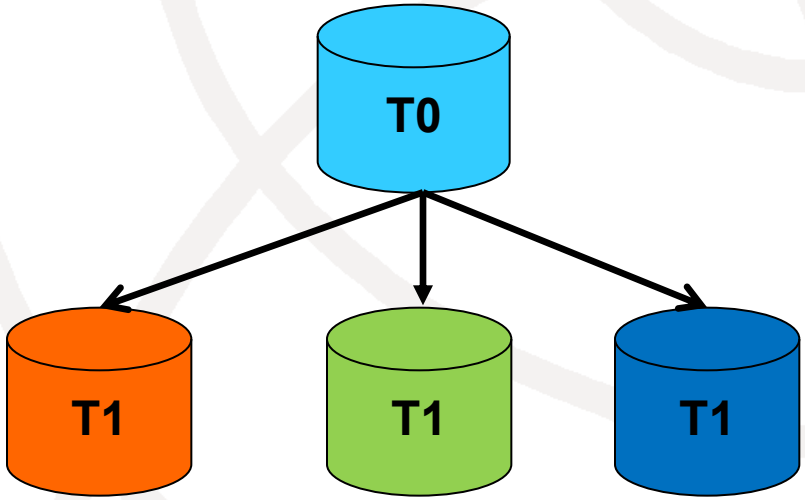
Where we are today

- Many companies are using ENUM for internal VoIP routing
- Some companies are using ENUM for inter-provider routing
  - Internal systems
  - Shared private systems
    - MMS using GRX
- Some federations are starting to build national registries

More of a Need Tomorrow

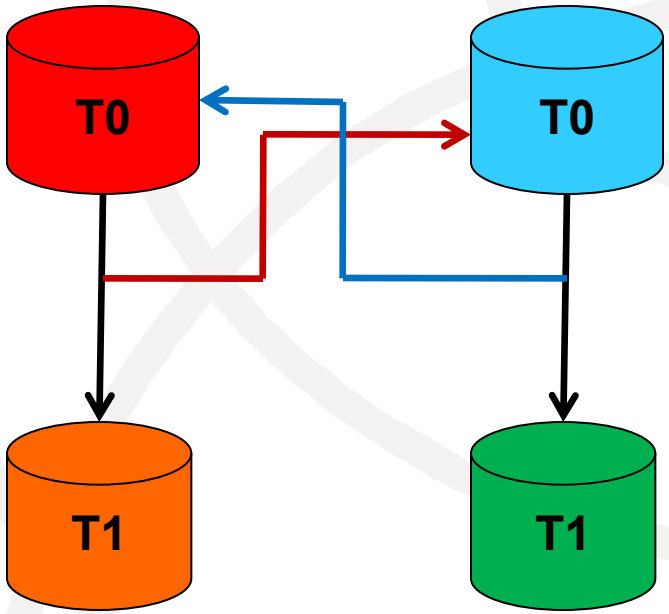
- Routing of VoLTE
- Key piece of IMS systems
  - Breakout to TDM/non-IMS
  - Beyond just voice

Global Tree Approach



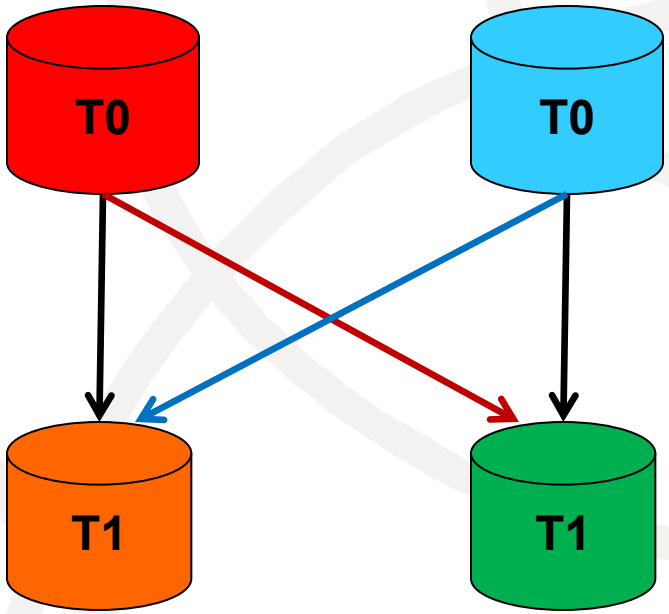
- Use agreed-upon established domain apex (e.g., e164enum.net)
- Use NS records for delegation between T0 and T1

Ad Hoc Federation Approach



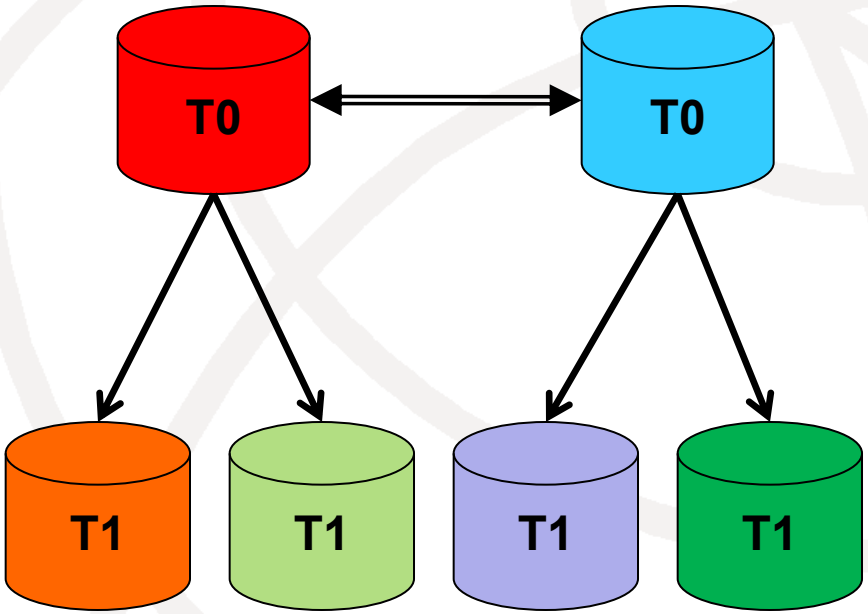
- No agreement on domain apex names
- T0's use NS records for T1's in their own federation
- T0's use DNAME for pointers to other federations' national implementations (at T0)

Cooperative Federation Approach



- Agreement on unified domain apex name
- Each federation has IP address of local T0 in cache
- Each federation shares name server info for T1's (name & IP address) & loads other federations' pointers into their T0
- Each T0 points to all T1's using NS records

Unified Federation Approach



- Agreement on unified domain apex name
- Each federation has IP address of local T0 in cache
- Each federation shares & loads copies of other federations' T1 data into its Registry

Conclusions and Recommendations

- What's holding us back?
  - Economy has not been kind to needed CAPEX
  - Some regulatory uncertainty
  - Demonstrated success
- Development needs
  - Front-end provisioning
  - System integration
    - Internally
    - Globally
  - Elusive third piece of the puzzle
    - ENUM-enabled apps
    - Network readiness