

# IP Transition: Why aren't we there yet?

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HENNING SCHULZRINNE

COLUMBIA UNIVERSITY & FCC

# Important issues I'll skip

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How do we ensure competition among voice services in a world of triple-play bundling?

How do we ensure competition for access circuits?

Who is responsible for backup power?

# But we'll talk about

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Architecture transitions

Legacy services

Phone numbers and communication identifiers

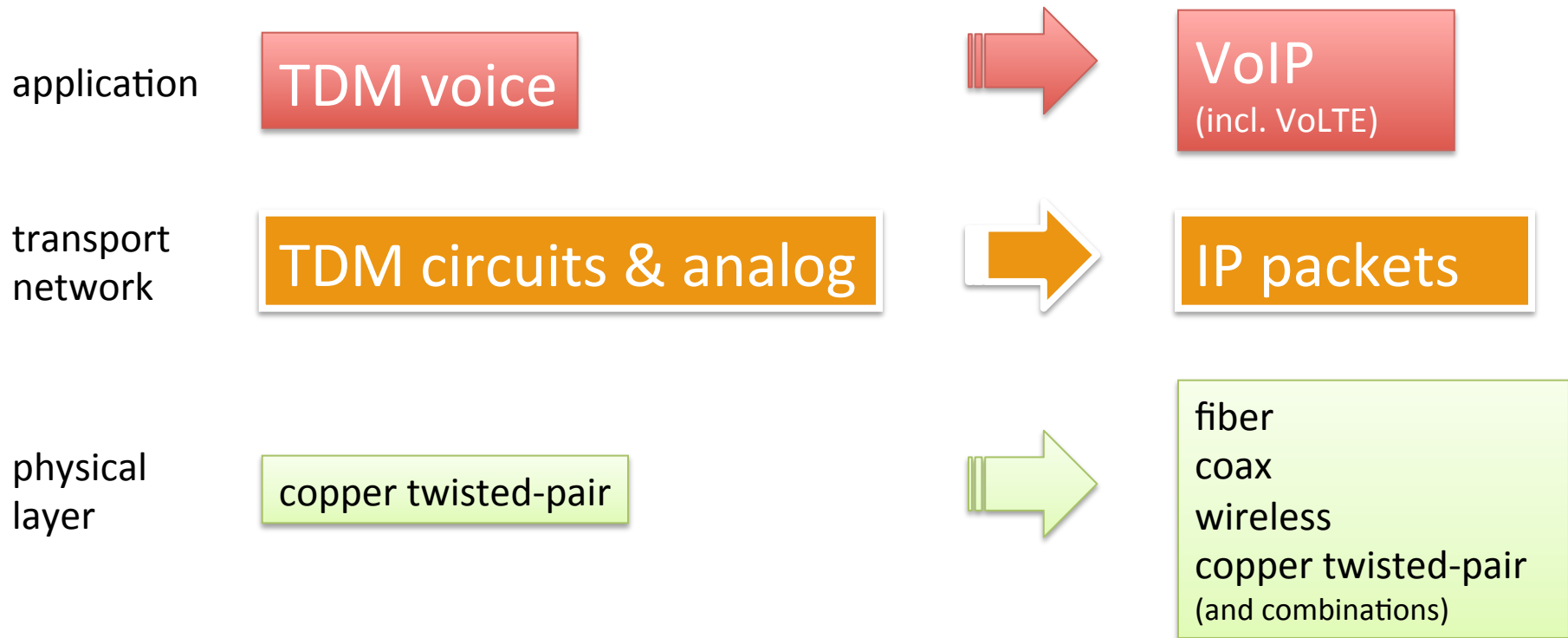
Robocalls

NG911

Functionally-equivalent communication

# Technology Transitions

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# The three transitions

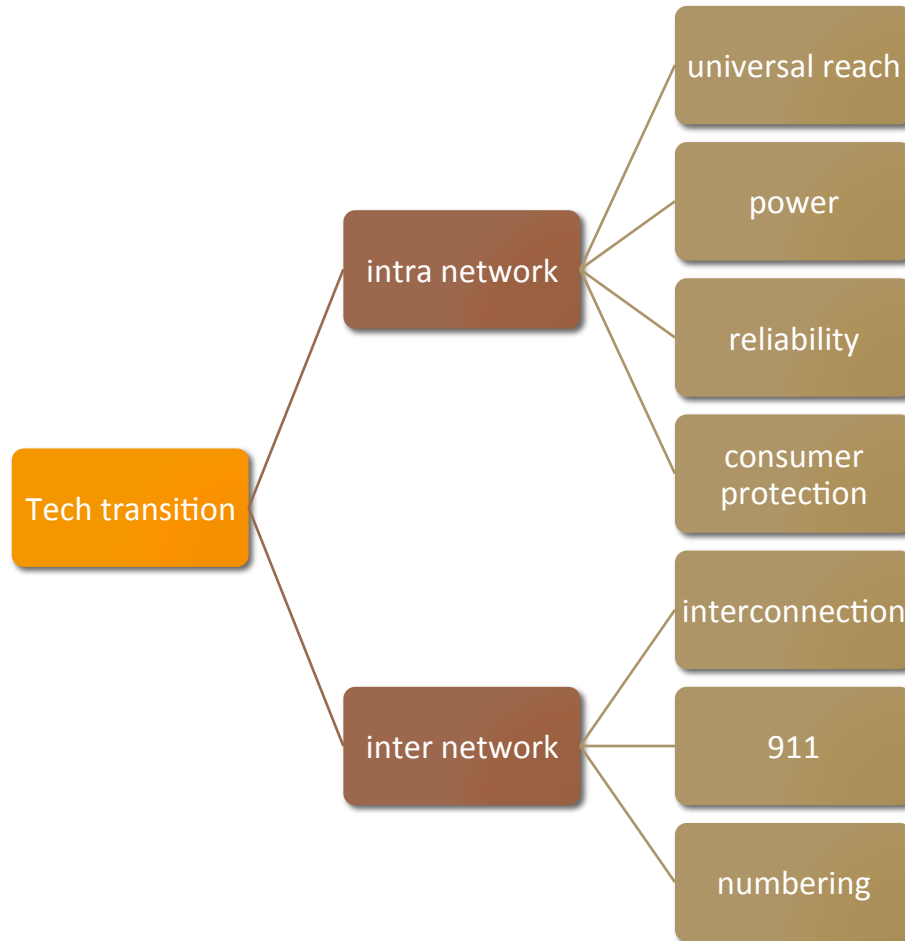
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From		to	motivation	issues
Copper	→	fiber	capacity maintenance <b>cost</b>	competition ("unbundled network elements")
Wired	→	wireless	mobility <b>cost</b> in rural areas	capacity quality
Circuits	→	packets (IP)	flexibility <b>cost</b> per bit	line power

VoIP,  
VoLTE

# Dividing the problem space

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# What has changed?

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	1990s	2015	2020?
<b>New services</b>	caller ID, voice mail	?	programmable
<b>media</b>	voice (+ fax)	voice + SMS	voice, video, text, real-time text?
<b>voice quality</b>	4 kHz	cellular	VoLTE, HD voice?
<b>robocalls</b>	local newspaper	“IRS”, “Microsoft”	none
<b>programmability</b>	VSC	web page	APIs?
<b>911</b>	phase I	phase II	NG911?

# Stack transitions



copper  
loops

technical bundle

1880s - 1996



UNE

1996-2000



economic bundle

copper  
HFC  
fiber  
4G

2000-2015+



RingCentral

4G/5G  
HFC  
fiber

2015+

# Switches are ageing



Nortel DMS-100

1979

ebay Browse by category

Back to search results | Listed in category: Computers/Tablets & Networking > Enterprise Networking, Servers > Other

This is a private listing. Sign in to view your status or learn more about private listings.

**FREE shipping**

**NT6X50AB DMS-100 DS1 Int**

Item condition: **Used**

Quantity:  3 available

Price: **US \$30.00**

Best Offer:

Bill Me Later New customers get \$10

I3telecom

# How do we transition legacy services?

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Service	Copper → fiber & (maybe) 4G	→ 3G wireless
Low-speed modem services: credit card terminals, gas meters, TTYs	transparent or converter	problematic
High-speed modems: fax	mostly	fail
Line-powered devices (elevator phones)?	fail	fail
Galvanic services	unavailable	unavailable
Timing (FAA)	NTP?	unavailable

# Could carrier voice fade?

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"If a carrier (including an ILEC) seeking to discontinue TDM voice service certifies that all affected retail customers have access to a "reasonably comparable alternative," that discontinuance request would be granted unless it is shown that such an alternative is not actually available," wrote CenturyLink in a FCC filing. "Such reasonably comparable alternatives would include facilities-based interconnected VoIP, circuit-switched, or 3G or 4G wireless service, provided by the discontinuing carrier or any other provider."

What's driving CenturyLink to ask for these permissions is the fact that a growing base of the customers it serves in its territories have either ditched their traditional landline voice service with a wireless service or are using VoIP. The telco said that one in three homes are "wireless only" and nearly a third of homes use a VoIP service.

Similar to other traditional ILECs, these trends have cut into CenturyLink's POTS (plain old telephone service) business. According to CenturyLink's projections, since "2000, ILECs in the 37 states that CenturyLink serves have lost over 70% of their residential lines."

# Identifiers

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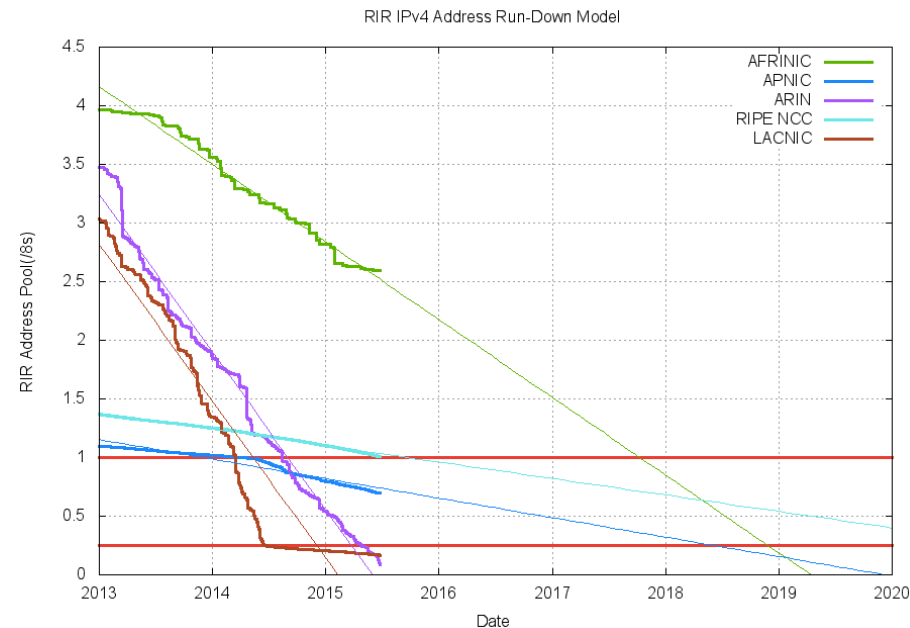


# Identifiers are boring & critical

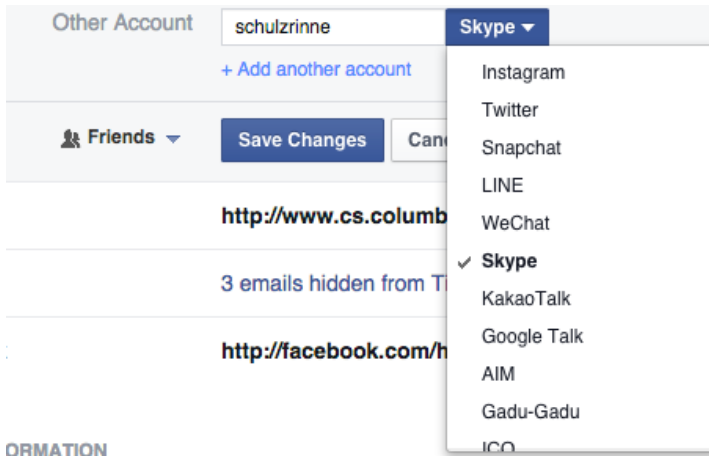
Identifiers define reachability, mobility and (sometimes) security

Identifiers are long-term architectural constants

- social security numbers
- MAC addresses
- IPv4 and IPv6 addresses
- phone numbers



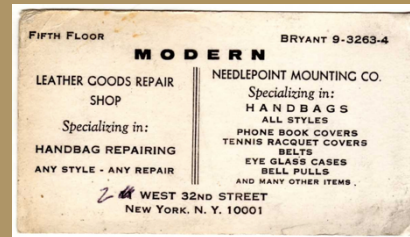
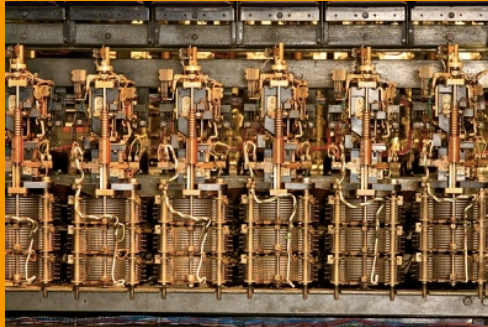
# Tower of Babble



specialization of  
communication tools



# Phone number evolution



# Communication identifiers

Property	URL owned	URL provider	E.164 phone numbers	Service-specific
Example	<a href="mailto:alice@smith.name">alice@smith.name</a> sip:alice@smith.name	<a href="mailto:alice@gmail.com">alice@gmail.com</a> sip:alice@ilec.com	+1 202 555 1010	www.facebook.com/alice.example
Protocol-independent	no	no	yes	yes
Multimedia	yes	yes	maybe (VRS)	maybe
Portable	yes	no	somewhat	no
Groups	yes	yes	bridge number	not generally
Trademark issues	yes	unlikely	unlikely	possible
I18N	technically, yes; humanly, no		yes	?
Privacy	Depends on name chosen (pseudonym)	Depends on naming scheme	mostly	Depends on provider “real name” policy

# Communication identifiers

Need identifier that

- can work on different media
- can be conveyed orally
  - try spelling email address...
- can work internationally
- is portable across organization
- does not reveal too much
- provides rough hint of geography & time zone



- I18N → number
- portable → no provider domain
- portable, privacy → no personal name
- geography → country-level assignment

Alternative:

- all app-world
- cryptographic identifier (public key) in address book



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華美銀行 — 您穩健的金融橋樑

聯合銀行業已加入華美銀行。華美銀行是總部設於加州的第二大商業銀行，總資產超過一百九十億元，是全美國實力最強大和最安全的銀行之一。

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<b>1.30% APY</b> 紅利金融市場帳戶	紅利金融市場帳戶： <ul style="list-style-type: none"><li>• 可隨時使用資金</li><li>• 提供優惠利率</li><li>• 安全有保障</li></ul>
<b>1.48% APY</b> 十個月高利率定存	十個月高利率定存： <ul style="list-style-type: none"><li>• 是您短期投資的最佳選擇</li><li>• 提供有保障的優惠利率</li></ul>

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# Phone numbers for machines?

212 555 1212  
< 2010



254 mio.



500 123 4567  
(and geographic numbers)



500 123 4567  
533, 544



12% of adults



5 mio.



311,000



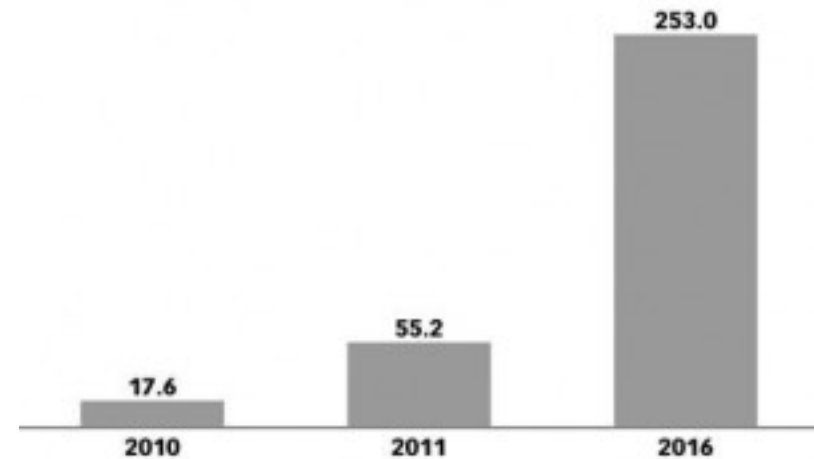
64 mio.



44.9 mio.

now: one 5XX code a year...  
(8M numbers)

**Tablet Shipments Worldwide, 2010, 2011 & 2016**  
millions of units



Source: Juniper Research, "Tablet & Ereader Evolution: Strategies & Opportunities 2011-2016" as cited in "Viva la Evolution," Sep 21, 2011

132763

www.eMarketer.com

10 billion +1 #'s available



# Phone numbers are valuable

In fact, cellphones have been proliferating in the city so rapidly that state regulators were notified on Friday that Manhattan will need yet another area code by late 2017.

Neustar, the company that manages the national phone-numbering system, told the Public Service Commission that all of the 646 numbers could be used up by then. Neustar's filing did not divulge what the new area code would be.

Theoretically, there are about 7.9 million phone numbers available per area code. It took about 45 years to use up all of the 212 numbers, but it will take only about 20 to exhaust the inventory of 646 numbers.

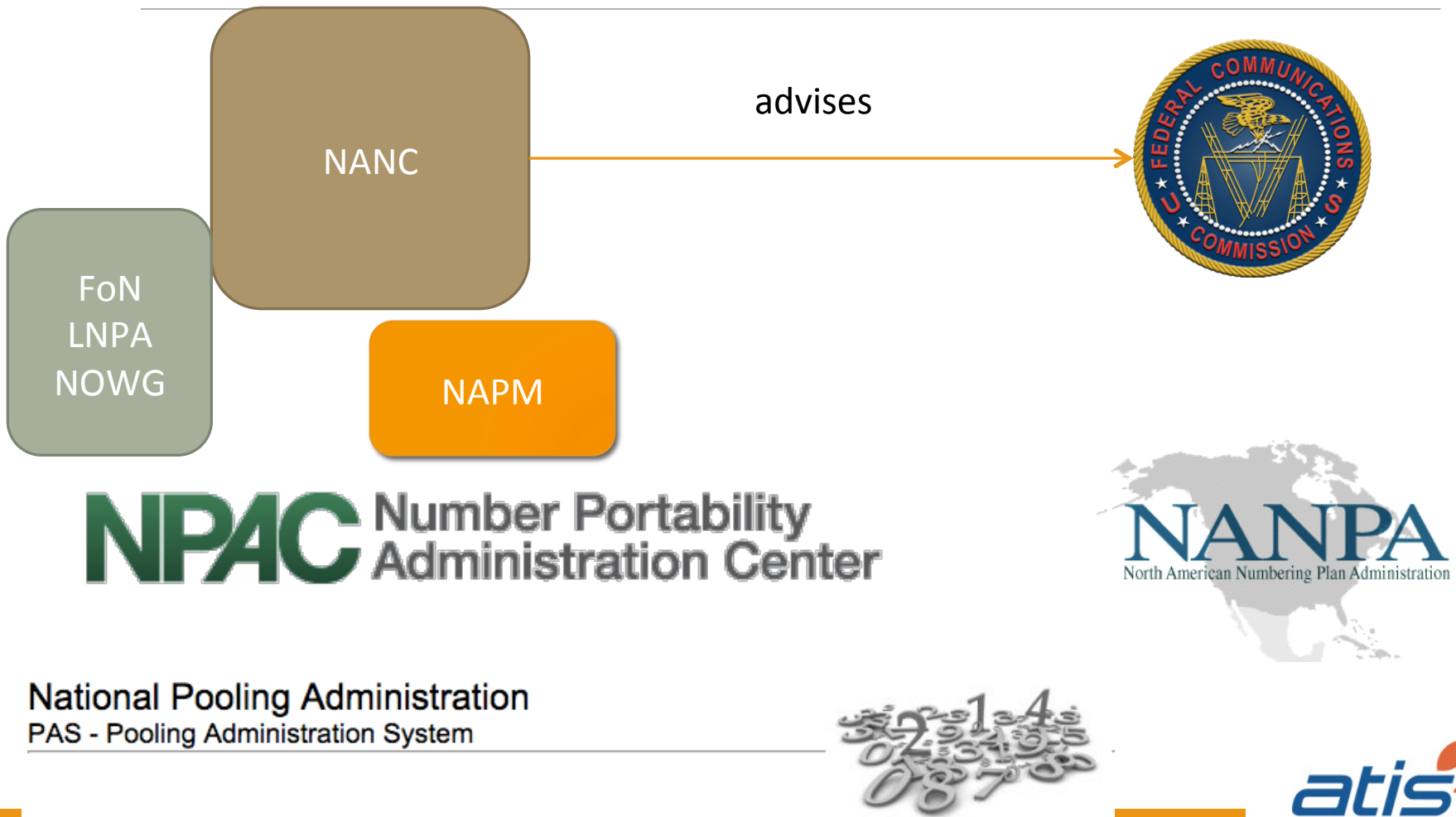
Weeks before signing a lease on an apartment on the Upper West Side, Mr. Lippitt, 36, purchased the phone numbers from a broker who buys and sells them. Normally, phone numbers are assigned without cost, but for several years 212 numbers have been selling for anywhere from \$75 to more than \$1,000.



the ultimate source for a  
212 area code phone number

call us  
(212) 580-2000

# Number administration is baroque





# Reconsider assumptions?

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NANPA, LNP, LERG, RespOrg, ... separation?

- NANP Administration System (NAS)
- Pooling Administration System (PAS)
- Number Portability Administration Center (NPAC)
- ➔ *Number Administration Database?*

numerous separate databases with often unclear data flows and opaque business models (e.g., CNAM, BIRRDs, LERG)

cross-modality portability is limited in arcane ways (rate center)

- porting from wireless to wireline may not work

# Dialing plans can be confusing

Location	NPA	Home NPA Local Calls	Home NPA Toll Calls	Foreign NPA Local Calls	Foreign NPA Toll Calls	Notes
CA	760	1+10D	1+10D	1+10D	1+10D	
CA	805	7D	7D	1+10D	1+10D	
CA	818	1+10D	1+10D	1+10D	1+10D	
CA	831	7D	7D	1+10D	1+10D	
CA	858	7D	7D	1+10D	1+10D	
CA	909	7D	7D	1+10D	1+10D	
CA	916	7D	7D	1+10D	1+10D	
CA	925	7D	7D	1+10D	1+10D	
CA	949	7D	7D	1+10D	1+10D	
CA	951	7D	7D	1+10D	1+10D	
CNMI	670	7D	1+10D	NA	1+10D	
CO	303	10D	1+10D	10D	1+10D	
CO	719	7D	1+10D	10D	1+10D	

1. Other dialing plans may apply at the discretion of the local service provider.
2. The Florida Keys retained 7D local dialing.
3. Home NPA local calls are 7D in Brevard County.
4. See Planning Letter 291 for local dialing into the 954-754 NPAs.
5. All Extended Calling Service (ECS) calls directed to a presubscribed carrier will be dialed as 1+10D (PL 311).
6. Some cross-boundary 7D local dialing exists.
7. Calls between the 551 and 201 NPAs may be dialed as 10D.
8. Calls between the 732 and 848 NPAs may be dialed as 10D.
9. Calls between the 973 and 862 NPAs can be dialed as 10D.

# Sample policy variables

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Who can get what kind of numbers?

- carriers and iVoIP providers
- organizational end users (companies)
- individuals

What rights do number holders have?

- Can they sell the number?
- Pass it on to others?

In what units?

- 1, 100, 1000?

Are numbers restricted (in use or portability)?

- by geography (NPA? LATA? rate center?)
- by service (mobile, SMS, “freephone”)?

Who pays for what?

- manage scarcity by administrative rules or economic incentives
- one-time or periodic renewal (800#, 10c/month)

What attributes are associated with a number?

- Who can read & write those attributes?

# Additional numbering uses?

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Numbers as long-term secure personal identifiers

- instead or along with email addresses
- with proof-of-possession validation
- already in almost all databases (bank, medical, IRS, ...)

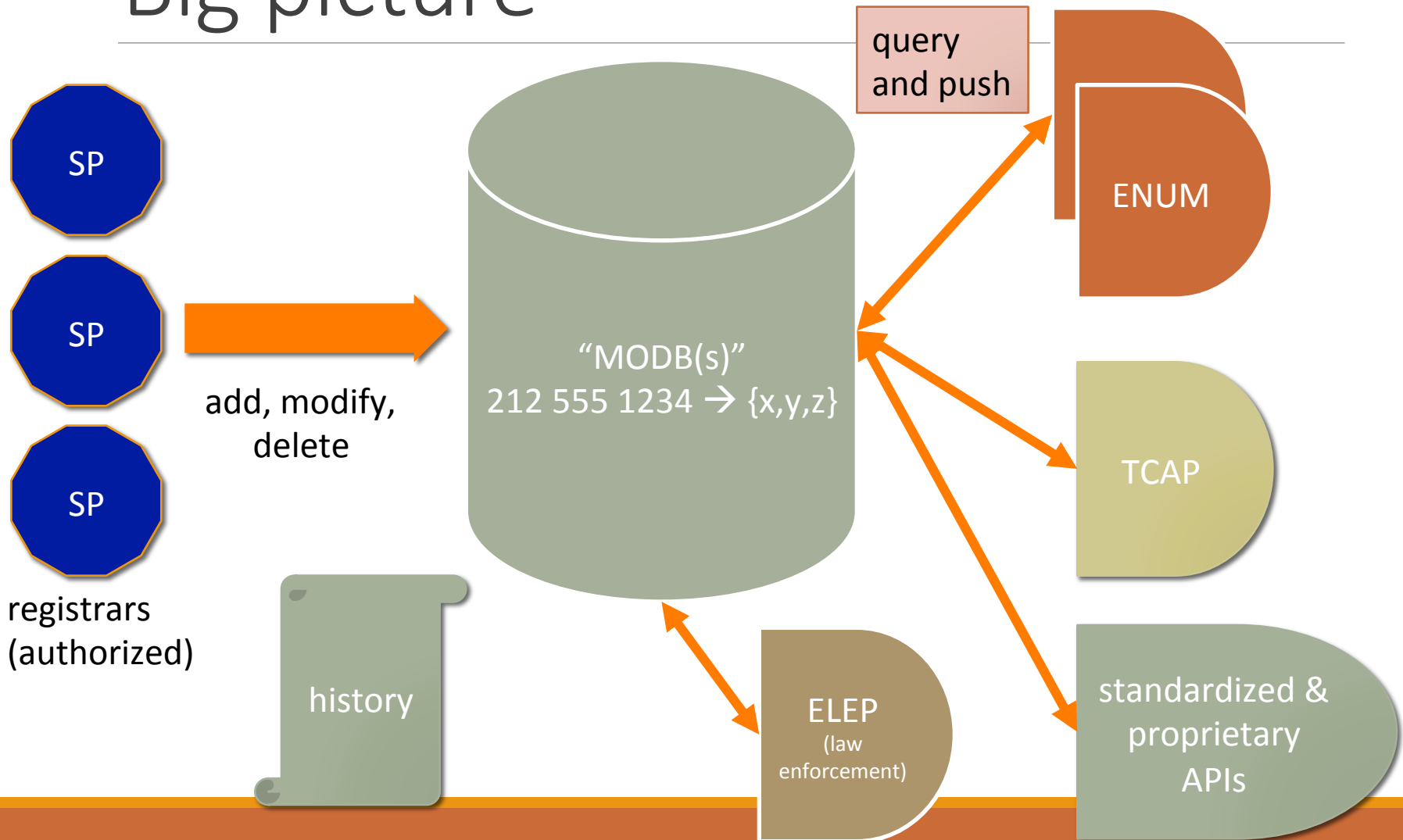
TCPA (“robocalling”)

- is this number a cell phone or a landline?

Validated or asserted attributes

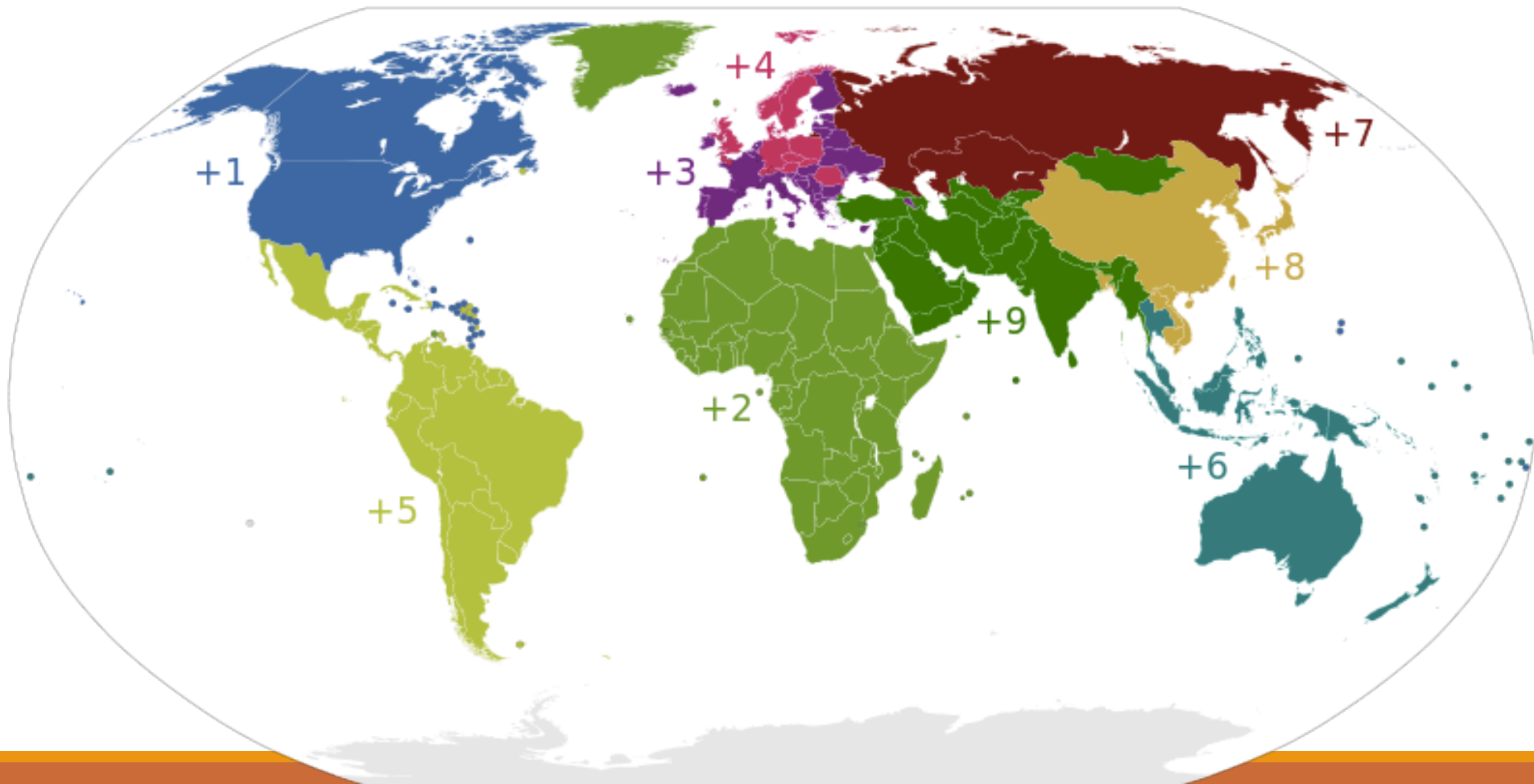
- “extended validation”
- e.g., geographic location, registered name, licenses

# Big picture



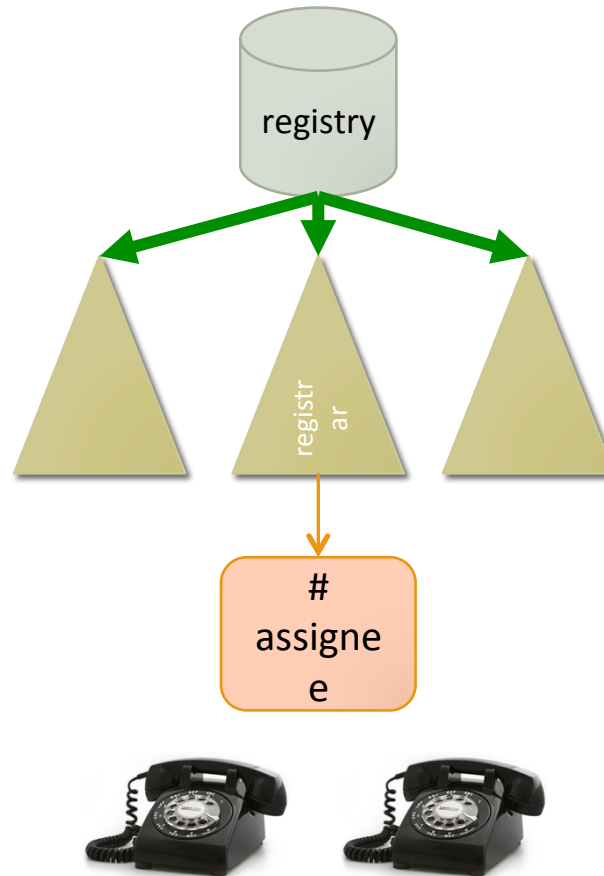
# Country dialing codes

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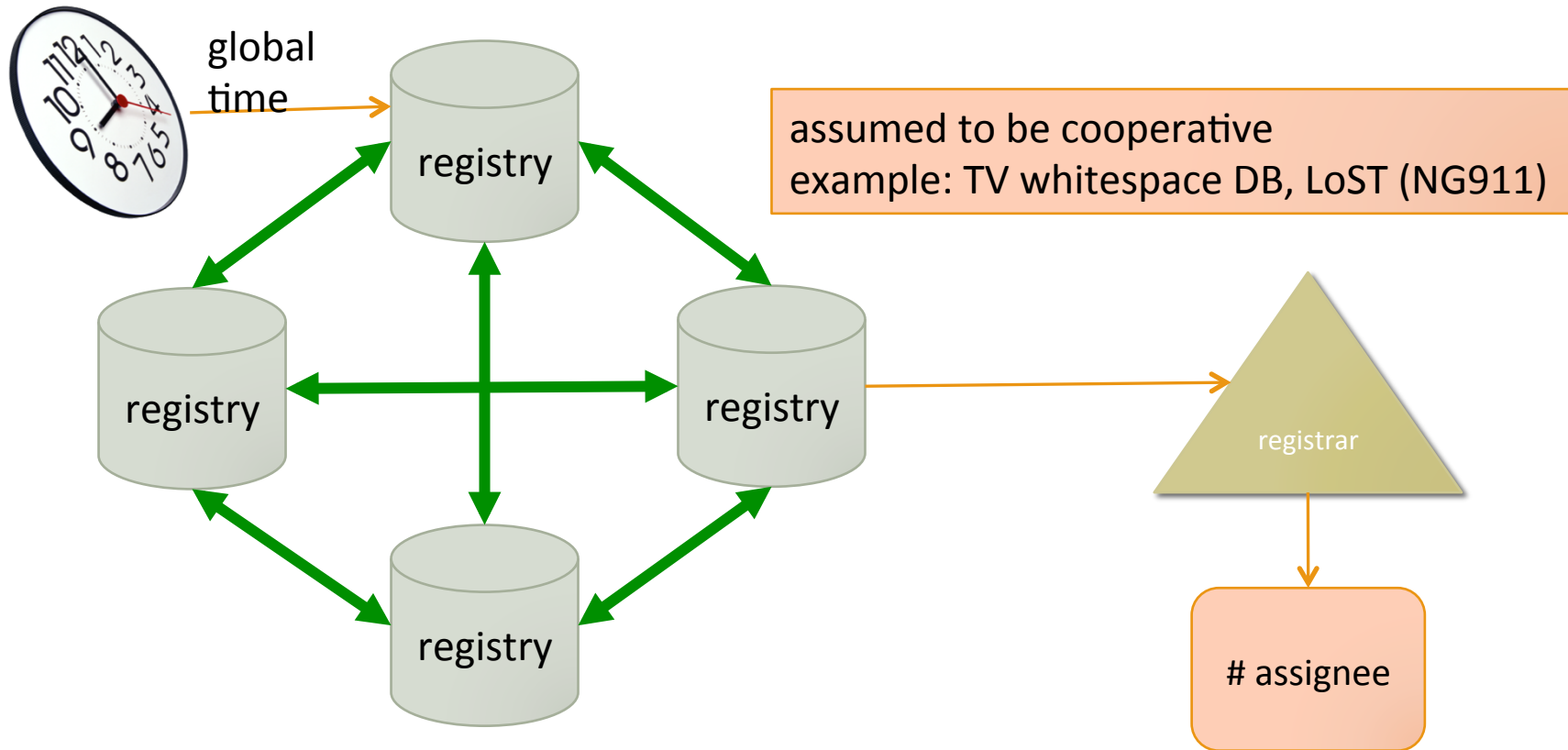


# Architecture 1: tree

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# Architecture 2: mesh + tree



- everybody has same information
- same state within N (7?) seconds
- revived nodes can catch up



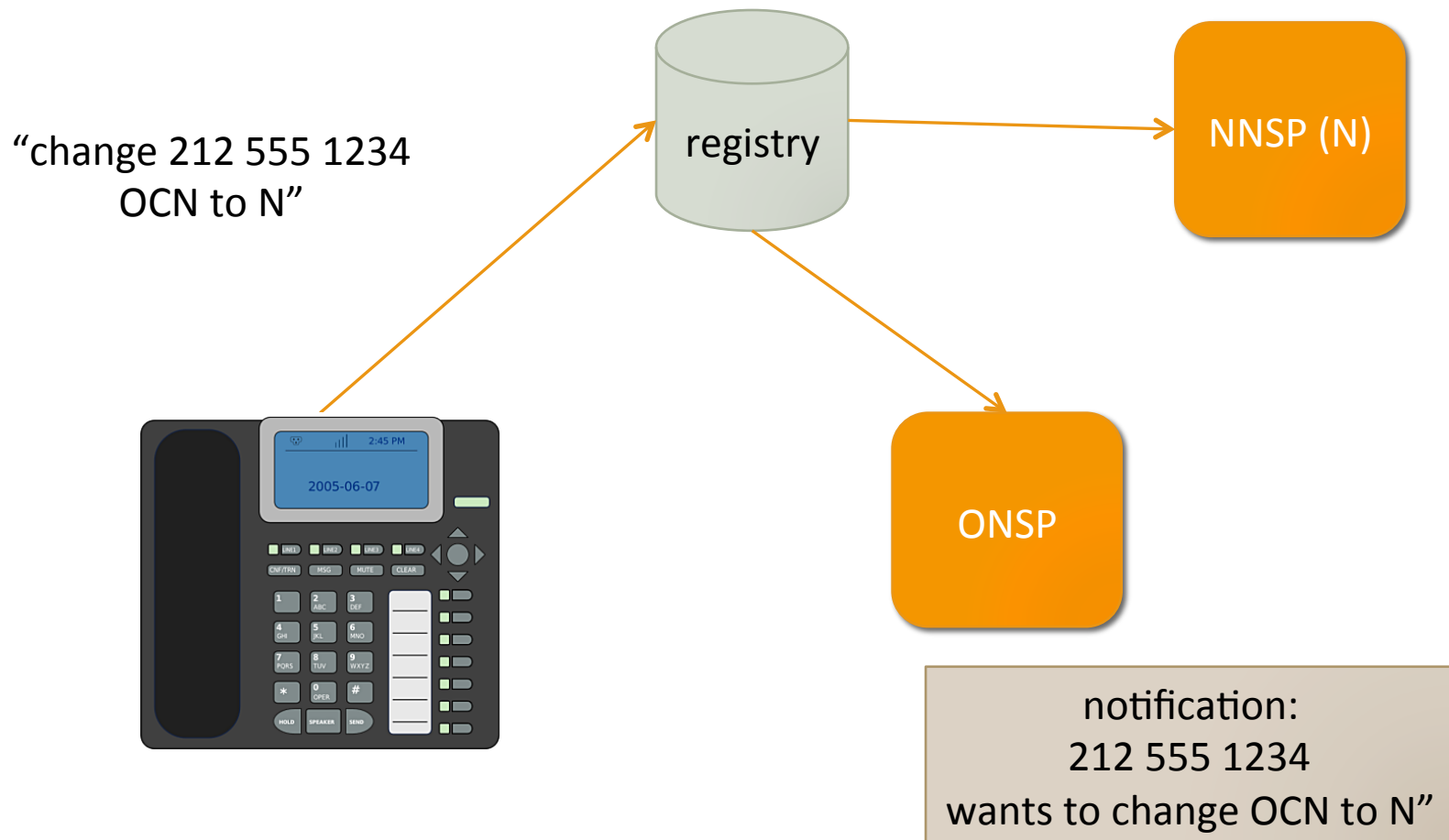


# Number meta-data (examples)

Data element	Comments
<b>E.164 number</b>	<b>key</b>
<b>OCN</b>	several for different media & geographic scope?
URL	routing URL
<b>Expiration date</b>	if records expire
Type of number	mobile, landline (TCPA), prison, hotel
Media	voice, video (ASL!), text
Rough location	e.g., ZIP+4 (for 311)
Public key	for STIR
whois record	similar to domain name?
Log entries (who, what, when)	need to be visible?
?	

most optional

# Porting: end user initiated



# IETF MODERN

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“Birds of a Feather” meeting held at Dallas IETF 92 meeting

General interest in exploring protocol space

Also: ATIS document on protocol testl



**Testbeds Landscape Team**

**Assessment and Next Steps**

March 2015

# IETF MODERN charter

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The MODERN working group will define a set of Internet-based mechanisms for the purposes of managing and resolving telephone numbers (TNs) in an IP environment. ... The traditional model of a TN having an association to a single service provider and a single application is breaking down. ... its use as an identifier for an individual or an organization will remain for some time. Devices, applications, and network tools increasingly need to manage TNs, including requesting and acquiring TN delegations from authorities. A sample of problems with existing mechanisms include:

- **lack of flexibility** (for example, it can be difficult to add fields without a very elaborate and lengthy process typically spanning years)
- **lack of distribution** (for example, it is hard or impossible to have more than one administrator for each database)
- **complexity** (leading ... to ... rural call completion problems ...)
- **difficulty of adopting more modern allocation** (e.g., "blocks" of 1) and **porting mechanisms**

# IETF MODERN charter

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- The work of this group will focus on **TNs, as defined in RFC3966**, and **blocks of TNs**, that are used to initiate communication with another user of a service. ... There is an expectation that aspects of the architecture and protocols defined by the working group will be reusable for other user-focused identifiers. .... Solutions and mechanisms created by the working group will be flexible enough to *accommodate different policies*, e.g., by different regulatory agencies.
- An architecture overview, including high level requirements and security/privacy considerations
- A description of the enrollment processes for existing and new TNs including any modifications to metadata related to those TNs
- A description of protocol mechanisms for accessing contact information associated with enrollments
- A description of mechanisms for resolving information related to TNs

# Pre-MODERN prototype

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Student semester prototype (Akhilesh Mantripragada & Abhyuday Polineni, Columbia Computer Science)

Try it yourself: [north.e164.space](http://north.e164.space)

Fully distributed cloud-based system (currently, 3 servers)

Ensures that only one entity can access a number at a time

Number Allocation Project: Please login as a Subscriber or Admin User to allocate new numbers, edit existing numbers or port numbers.

- resolves simultaneous access by majority vote

No single point of failure

PIN-based porting model

- consumer gets or sets PIN via web page
- provides PIN to gaining carrier



# Prototype

+ NUM-ALLOC

Home

Admin

Number List

Add New Number

Port A Number

OCN List

Area Code List

Manage System and Number Admins

Reset Password

Edit Profile

Show 10 entries

Search by Number, OCN, Location, SPID, or Service Indicator:

+ Add New

Number	CNAM	OCN	Assignee	Location	Collect	Service Indicator	Type	Log	View/Edit Entry?
2015926696	Henning Schulzrinne	1510	Columbia University	Leonia, NJ 07605, USA	allow	1	mobile	Log	View/Edit
2106396367	Akhilesh Mantripragada	42	China Tel. Co.	New York, NY 10025, USA	allow	Private	mobile	Log	View/Edit
2106396368	Akhilesh	42	Dixville Tel. Co.	New York, NY 10025, USA	allow	Private	mobile	Log	View/Edit
2106396369	Akhilesh 2	42	Dixville Tel. Co.	New York, NY 10025, USA	allow	Private	mobile	Log	View/Edit

# Prototype

Home

Admin/Associate Access

Edit Details

Alloted Number

2015926696

CNAM

Henning Schulzrinne

OCN Information

1510

Assignee Information

Columbia University

Certificate

[Certificate Link](#)  No file chosen

Zip Code

07605

Location

Leonia, NJ 07605, USA

Operating Telephone Company (OTC)

1234



# Reducing Public Nuisance #1

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## Users

Search  
LCD Directory  
Hunt Groups  
Search  
Page Groups  
Search  
Call Pickup Groups  
Search  
Attendant Console  
Media Access Control  
Patterns  
URI Translation  
Class of Service  
Elements  
Type of Service  
Dial Plans  
Dial Rules  
Emergency Services  
System Speed Dials  
Button Mappings  
Call Park  
Camp On

## URI Translations

Found 34 Translation(s)

Add URI Translation Delete Selected

	Group Name	Source Pattern ▲	Result Source Pattern	Destination Pattern	Result Destination Pattern	Active	Action
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	*@*	*@*	sip:*@cs.columbia.edu	sip:*@128.59.23.13	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:90*@128.59.23.13	sip:0*@128.59.23.13	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:99@*	sip:12128545555@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:0@128.59.23.13	sip:0@vcxdigimg.cs.columbia.edu	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:9911@*	sip:911@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:*@vcxsec1.cs.columbia.edu	sip:*@128.59.23.13	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:*@vcxpr1.cs.columbia.edu	sip:*@128.59.23.13	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:*@128.59.23.15	sip:*@128.59.23.13	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:2129397000	sip:2129397000	sip:4*@128.59.23.13	sip:1212854*@vcxdigimg.cs.columbia.edu	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:2129397000	sip:2129397000	sip:1*@128.59.23.13	sip:1212851*@vcxdigimg.cs.columbia.edu	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:2129397000	sip:3*@128.59.23.13	sip:1212853*@vcxdigimg.cs.columbia.edu	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:91*@128.59.23.13	sip:*@128.59.23.13	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:*@columbia.edu	sip:*@128.59.23.13	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:*@vcx.cs.columbia.edu	sip:*@128.59.23.13	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:*	sip:*	sip:911@*	sip:911@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:0*	sip:0*	sip:0*@vcxdigimg.cs.columbia.edu	sip:0*@vcxdigimg.cs.columbia.edu	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:1*	sip:1*	sip:91*@128.59.23.13	sip:1*@vcxdigimg.cs.columbia.edu	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:1*@128.59.23.20	sip:1*@128.59.23.20	sip:91*@128.59.23.13	sip:1*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:1*@128.59.23.20	sip:91*@128.59.23.20	sip:*@128.59.23.13	sip:*@128.59.23.13	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:1*@128.59.23.20	sip:91*@128.59.23.20	sip:6*@128.59.23.13	sip:6*@128.59.23.13	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:1*@128.59.23.20	sip:91*@128.59.23.20	sip:7*@128.59.23.13	sip:7*@128.59.23.13	N	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:6*	sip:6467756*	sip:9011*@128.59.23.13	sip:011*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:6*	sip:6467756*	sip:3*@128.59.23.13	sip:1212853*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:6*	sip:6467756*	sip:91*@128.59.23.13	sip:1*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:6*	sip:6467756*	sip:1*@128.59.23.13	sip:1212851*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:6*	sip:6467756*	sip:4*@128.59.23.13	sip:1212854*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:7*	sip:2129397*	sip:9011*@128.59.23.13	sip:011*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:7*	sip:2129397*	sip:3*@128.59.23.13	sip:1212853*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:7*	sip:2129397*	sip:4*@128.59.23.13	sip:1212854*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:7*	sip:2129397*	sip:1*@128.59.23.13	sip:1212851*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:7*	sip:2129397*	sip:91*@128.59.23.13	sip:1*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:7131@128.59.23.13	sip:3115552368@128.59.23.13	sip:91*@128.59.23.13	sip:1*@vcxdigimg.cs.columbia.edu	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:7131@128.59.23.13	sip:3115552368@128.59.23.13	sip:7*@128.59.23.13	sip:7*@128.59.23.13	Y	<a href="#">Delete</a>
<input type="checkbox"/>	<a href="#">Virtual Private Network</a>	sip:91*@128.59.23.20	sip:1*@128.59.23.20	sip:91*@128.59.23.13	sip:1*@vcxdigimg.cs.columbia.edu	N	<a href="#">Delete</a>

Prev Page 1 of 1 Next

sip:7131@128.59.23.13  
sip:7131@128.59.23.13

sip:3115552368@128.59.23.13  
sip:3115552368@128.59.23.13

(311) 555-2368



Remind Me



Message



Decline



Accept

AT&T

INCOMING CALL



(311) 555-2368



Mute



Speaker

DECLINE

ANSWER

# Robocalls: 7 Roads to Happiness

Prevent caller ID spoofing

- STIR

Clean up CNAM

- identify data sources
- more information

Allow consumer-driven filtering

- unwanted vs. illegal calls

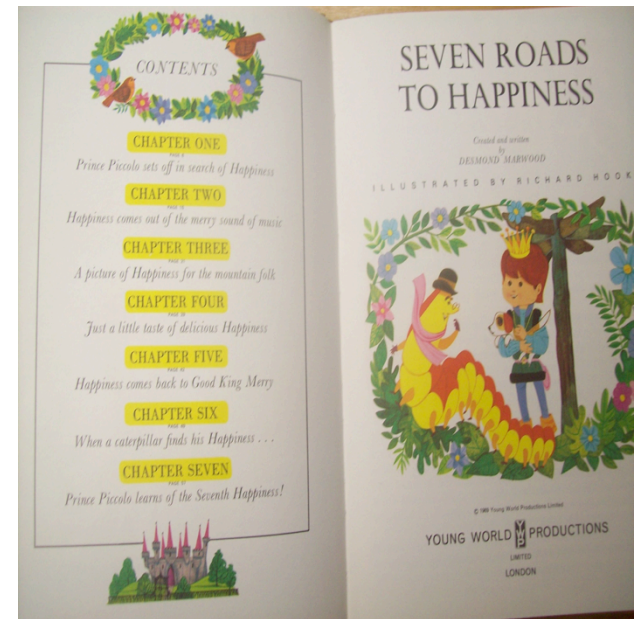
Ensure interconnection works

- signature must survive interconnection
- SIP display name must survive

APIs for third-party filtering

Apps for smartphones

Do Not Originate as a short-term measure



"People take different roads seeking fulfillment and happiness. Just because they're not on your road doesn't mean they've gotten lost."

— Dalai Lama XIV

# STIR (number signing) status

## Secure Telephone Identity Revisited (stir)

Documents

[Charter](#)

[History](#)

[Dependency Graph](#)

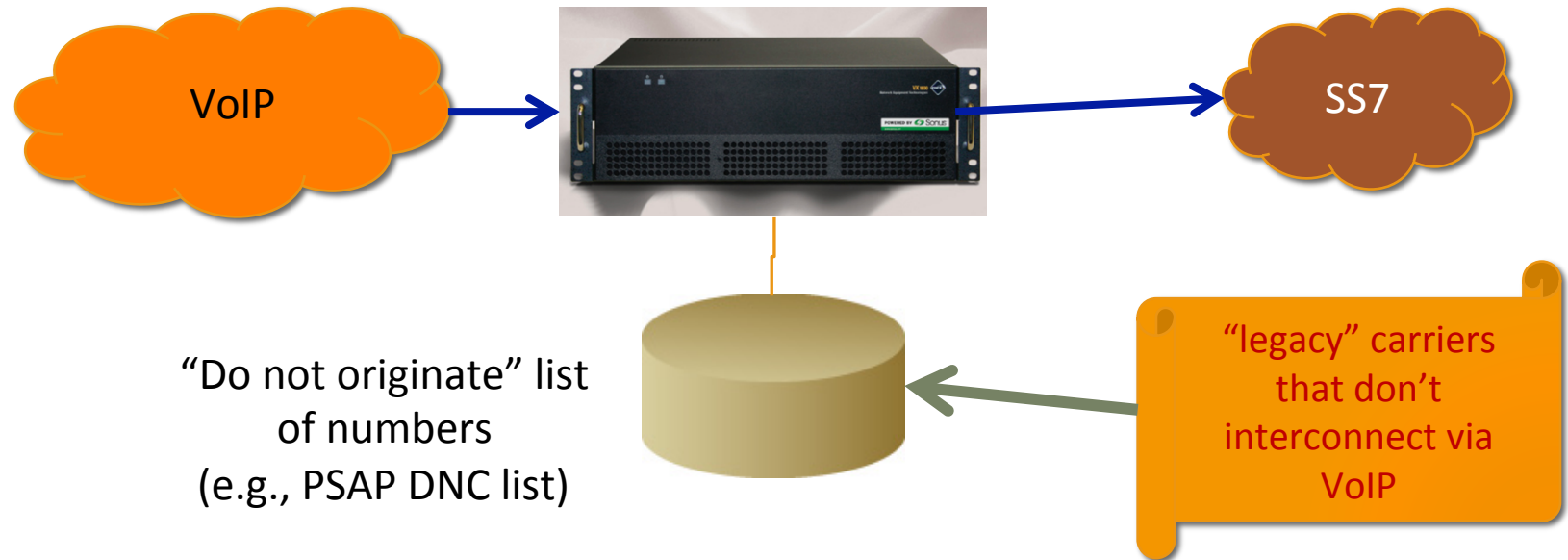
[List Archive »](#)

[Tools WG Page »](#)

Document	Date	Status
<b>Active Internet-Drafts</b>		
<a href="#">draft-ietf-stir-certificates-01</a>	2015-03-25	I-D Exists
<b>Secure Telephone Identity Credentials: Certificates</b>	12 pages	WG Document
<a href="#">draft-ietf-stir-rfc4474bis-03</a>	2015-03-10	I-D Exists
<b>Authenticated Identity Management in the Session Initiation Protocol (SIP)</b>	31 pages	WG Document
<b>RFCs</b>		
<a href="#">RFC 7340</a> ( <i>was draft-ietf-stir-problem-statement</i> )	2014-09	Informational RFC
<b>Secure Telephone Identity Problem Statement and Requirements</b>	25 pages	Submitted to IESG for Publication
<a href="#">RFC 7375</a> ( <i>was draft-ietf-stir-threats</i> )	2014-10	Informational RFC
<b>Secure Telephone Identity Threat Model</b>	13 pages	Submitted to IESG for Publication

# Do Not Originate (DNO)

- Premise: almost all illegal robo-calls originate on VoIP
- Thus, gateways as filter for numbers that *shouldn't be there* (e.g., IRS or banks)



# DNO: How do numbers get onto the list?

911 DNC list

Financial  
institutions

Government  
agencies

NANPA:  
unassigned  
numbers

TDM carrier  
numbers

Facilities-  
based VoIP  
(with own gateways)

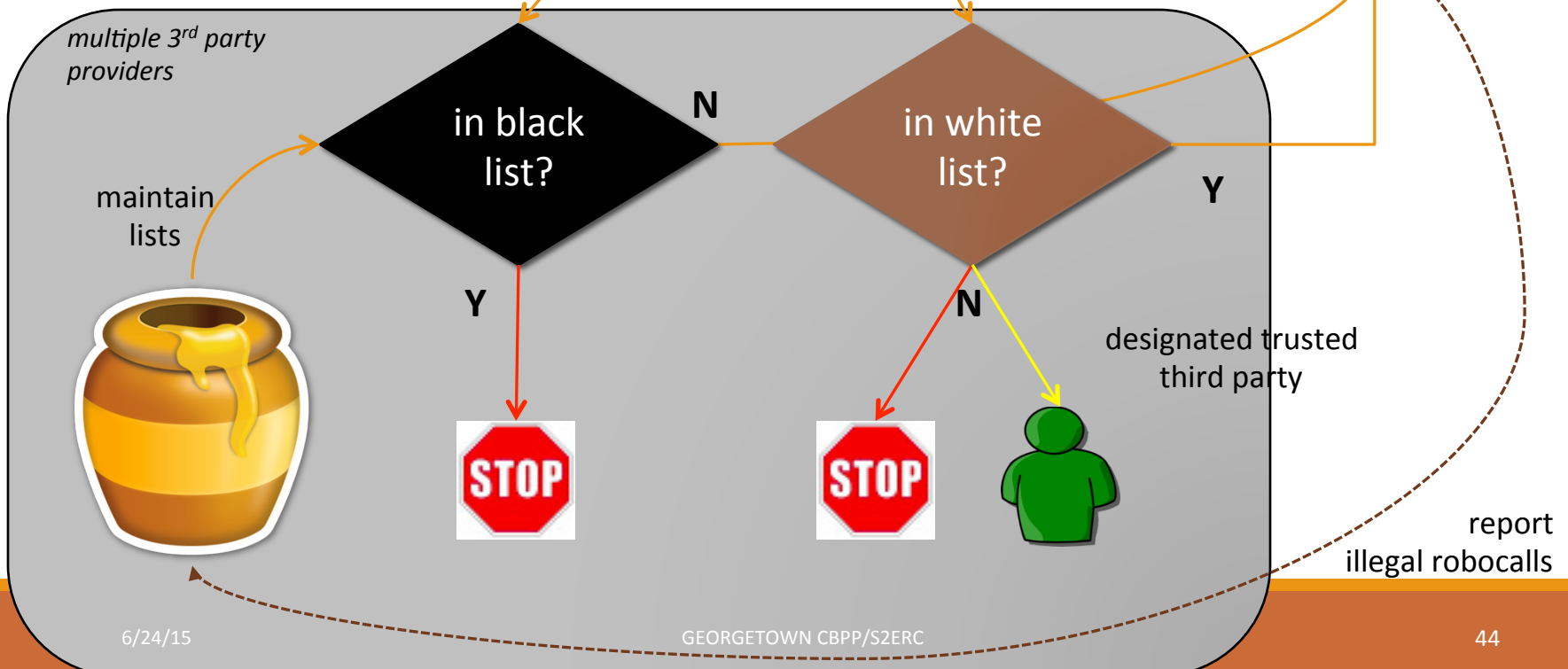
OTT VoIP (except for  
contracted GWs)

# Automated call blocking

WHITE LIST

for vulnerable populations, allow only:

- address book entries
- government agencies
- medical providers
- emergency alerts





# Caller name (CNAM) improvements

## 15 character limit

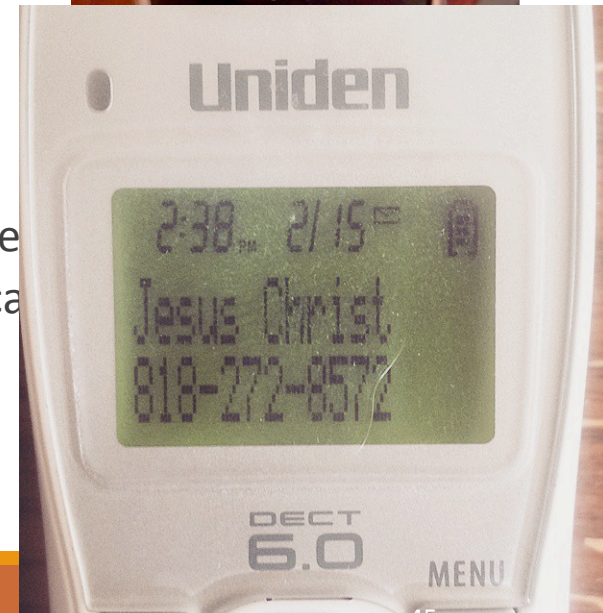
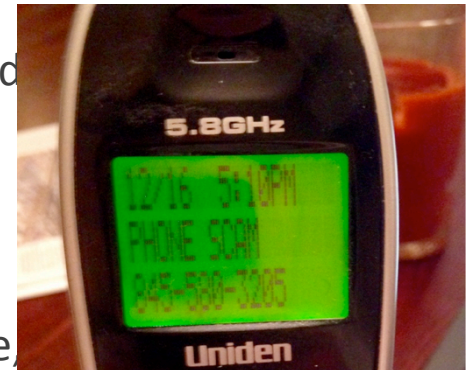
- mostly due to legacy displays and Bell 202 1200 baud mod
- signaling allows larger data elements

## Disallows

- full names → awkward abbreviations
- more information – caller name and affiliation (“John Doe Chicago”)
- no credentials (license, registration)

## Architecture issues

- multiple providers → difficult to correct errors or prevent
- CNAM dip fees → kickback schemes that enable robocall
- unclear provenance of information



# 911 in an all-IP world

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# 911 deployment challenges

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Three movies, same plot:

- Phase II location (cellular)
- Text-to-911
- NG911

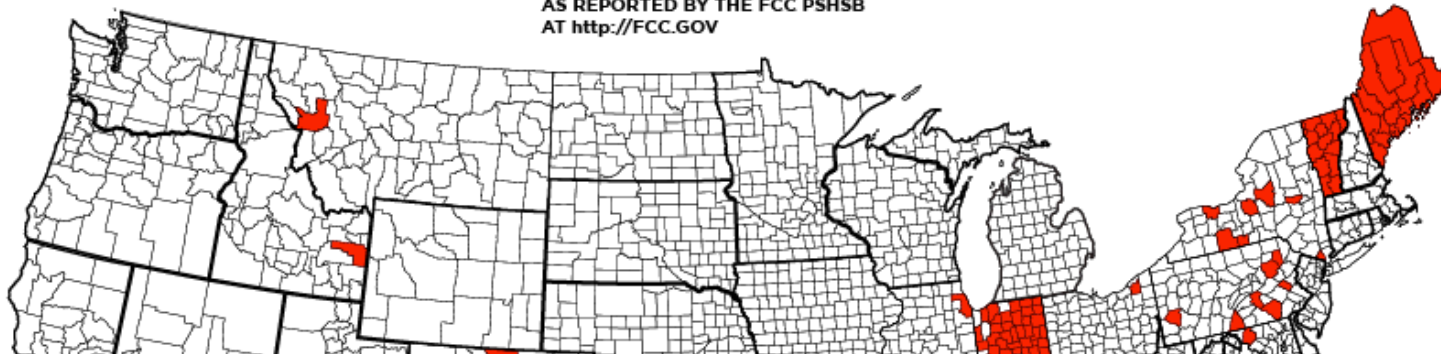
Reasons for delay include:

- bottom-up deployment → consultant employment guarantee
- local control → local technology assets
- no regional, state or national funding mechanisms
- often, no state leadership
- slowest PSAP determines speed
- limited technical expertise at grass roots level
- uncooperative carriers (“Selective routers forever!”)
- unclear responsibility boundaries between carriers and PSAPs/ESInets

# Text-to-911

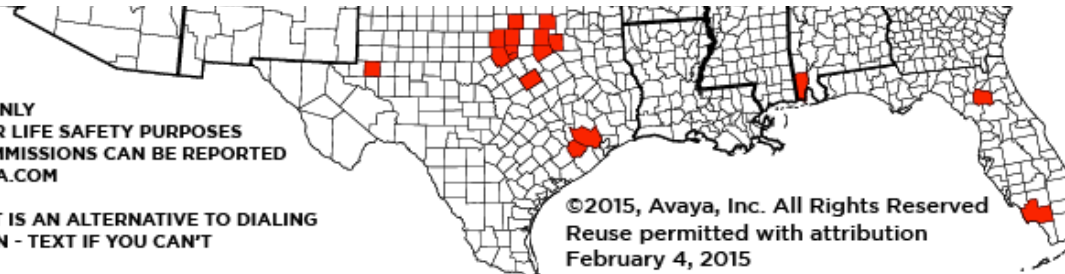
## TEXT to 9-1-1 DEPLOYMENTS IN THE US AS OF FEBRUARY 4, 2015

AS REPORTED BY THE FCC PSHSB  
AT <http://FCC.GOV>



NEWS

## Text-to-911: Only 5% of emergency dispatch centers support it



INFORMATION ONLY  
DO NOT USE FOR LIFE SAFETY PURPOSES  
ERRORS AND OMISSIONS CAN BE REPORTED  
TO [NG911@AVAYA.COM](mailto:NG911@AVAYA.COM)

REMEMBER TEXT IS AN ALTERNATIVE TO DIALING  
CALL IF YOU CAN - TEXT IF YOU CAN'T

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Reuse permitted with attribution  
February 4, 2015

# Caller location

Builds on long history of FCC location accuracy requirements

- implicitly outdoor: 50m (67%)/150m (80%-90%) circles (1996), with geographic exclusions

dispatchable location or x/y within 50 m

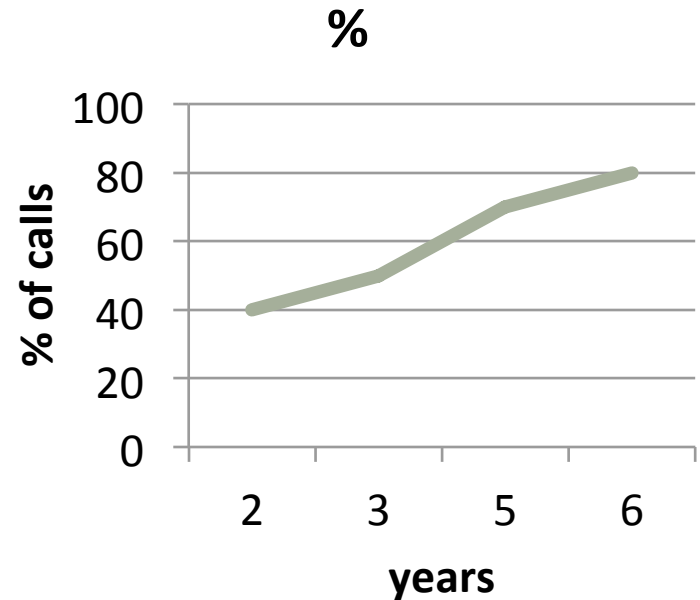
- ~70% calls are wireless
- unknown % indoor
- residential indoor may allow GPS

z axis:

- 3 years: uncompensated barometric
- 6 years: 80% of top 25 CMAs

open issues:

- nomadic iVoIP
- separation of location & call delivery



# Alternative 911 network models

## Current deployment model

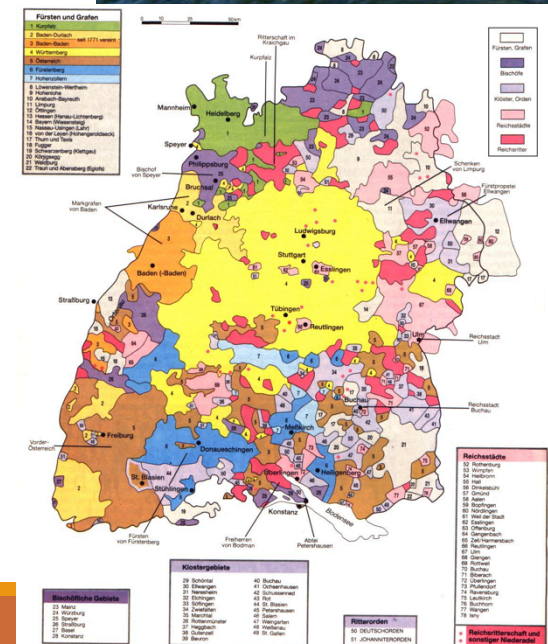
- network islands (ESInets) with SBC moats
- one county, one network, one server rack, one purpose, one decade

## Similar to early academic Internet → Internet2

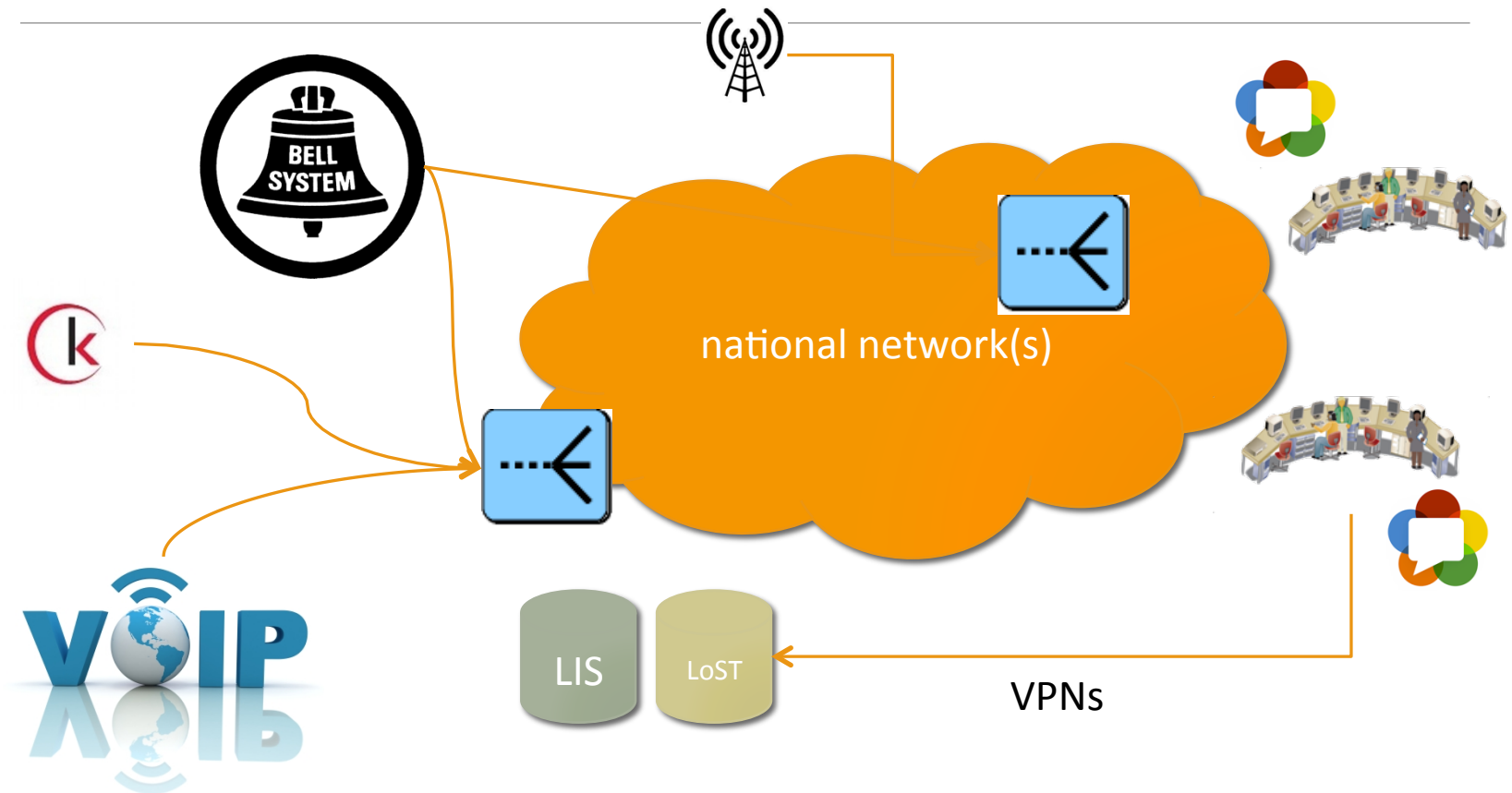
- initially custom, then re-use dark fiber
- membership model?



Suomenlinna



# Alternative network models



major network interconnect points:  
SEA, LAX, SJC, DEN, CHI, BOS, DC, NYC



# Alternative network models

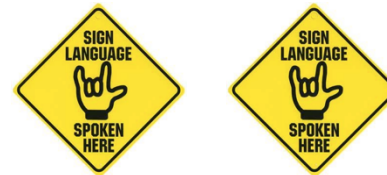
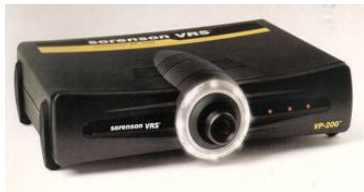
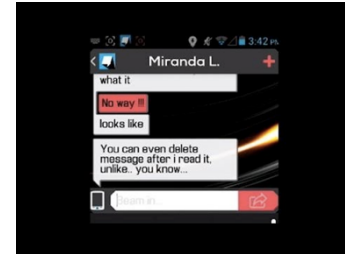
old model: one 99.999% network

new model: 7 99% networks → 99.999999999999999% (in theory...)





# Functionally-equivalent communication



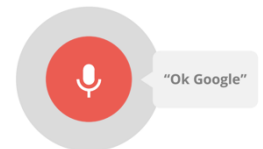
direct video communication



human-assisted  
ASR



automated  
speech-to-  
text



# Conclusion

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Hard parts of the IP transition:

- require intra/inter-industry coordination
- limited incentive to change (for some)
- limited willingness to invest
- waning skill sets
- all blame, no credit

If you don't just want to be a bit pipe, create valuable services

- user controllable
- not just a nuisance (“I don't pick up my phone any more”)

# Backup

---

# LERG



experience  
performance  
results

Operating Company Numbers, Company Names, Routing Contacts

Country Code Assignments

NPA Information (i.e., Area Codes)

LATA Codes By Region

Destination Codes (i.e., NPA NXX and Thousands-Blocks) (details on over 750,000 assignments)

Oddball NXXs (e.g. 911, 976)

Switching Entity Record detail (e.g. Equipment Type, V&H Coordinates)

Rate Center details (e.g. V&H Coordinates) and Localities (including county and postal codes)

Switch Homing Arrangements (tandem and other switch-to-switch interconnections)

Operator Access Tandem Codes (ATCs)

Location Routing Numbers (LRNs)

# Number porting models: token

## Transfer:

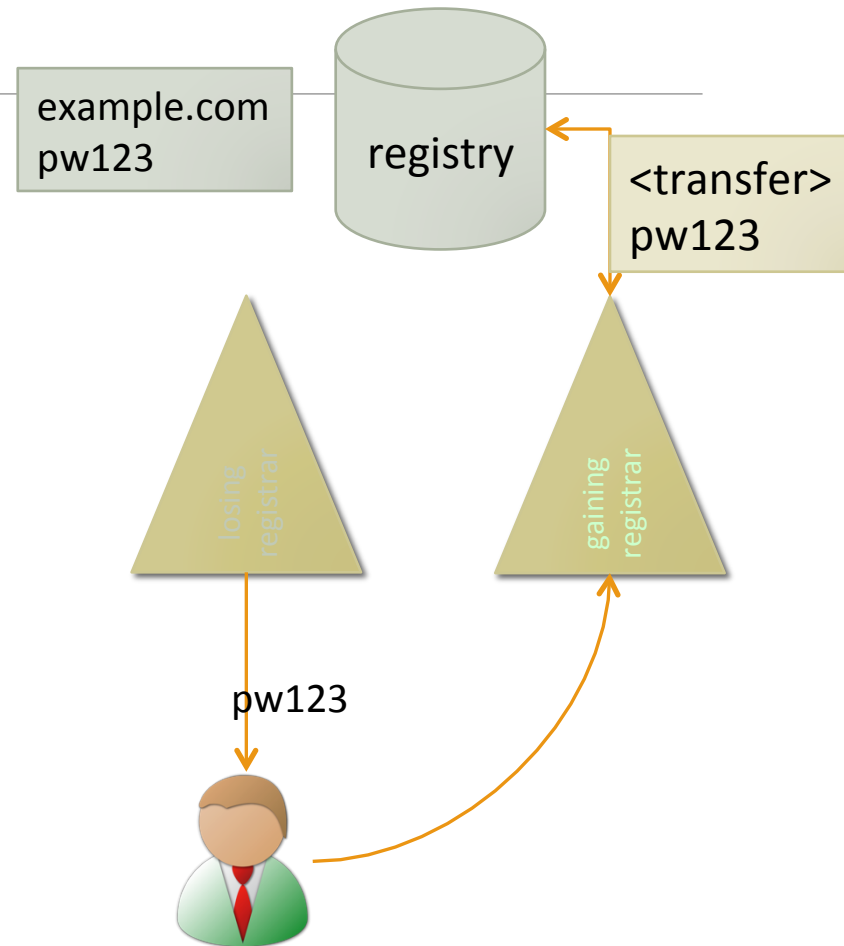
- *registrar 1* → *registrar 2*

## Porting:

- *provider 1* → *provider 2* (in EPP, that's an **<update>**)

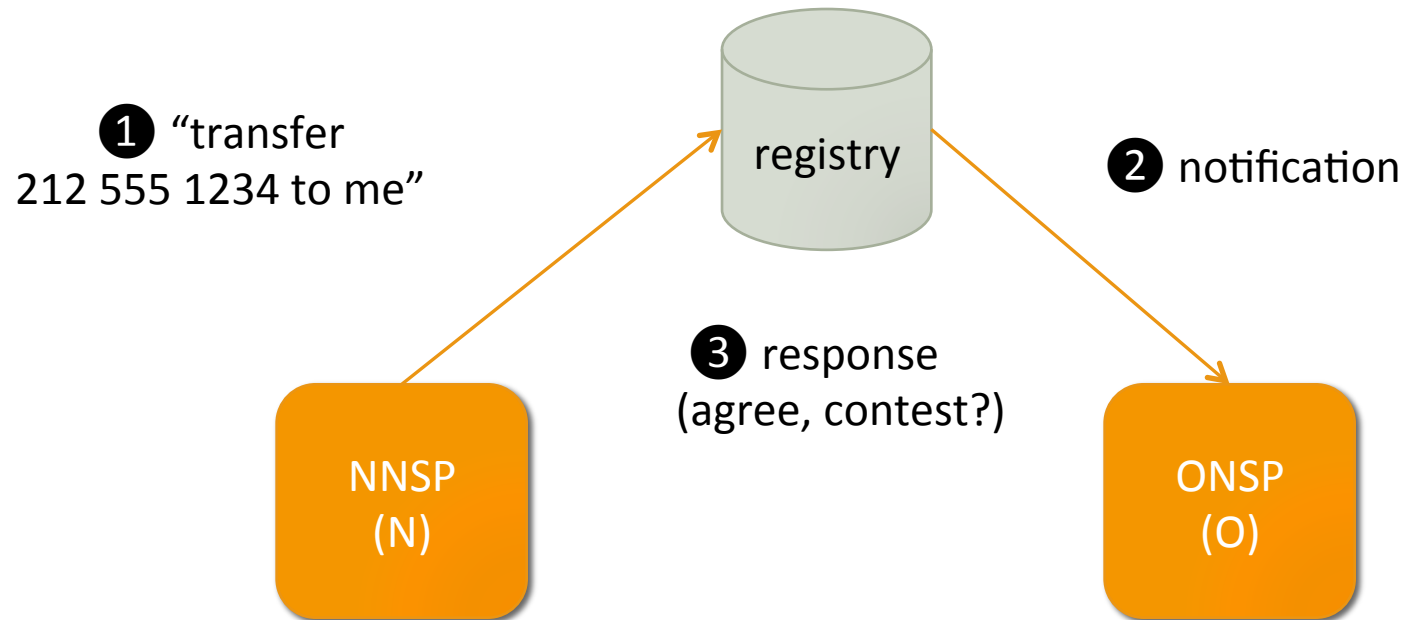
## Token model (“AuthInfo” in EPP)

- current registrar provides secret token to assignee
  - or assignee inserts random token via registrar
- assignee provides token to gaining registrar/carrier
- OAuth bearer token (RFC 6750)?



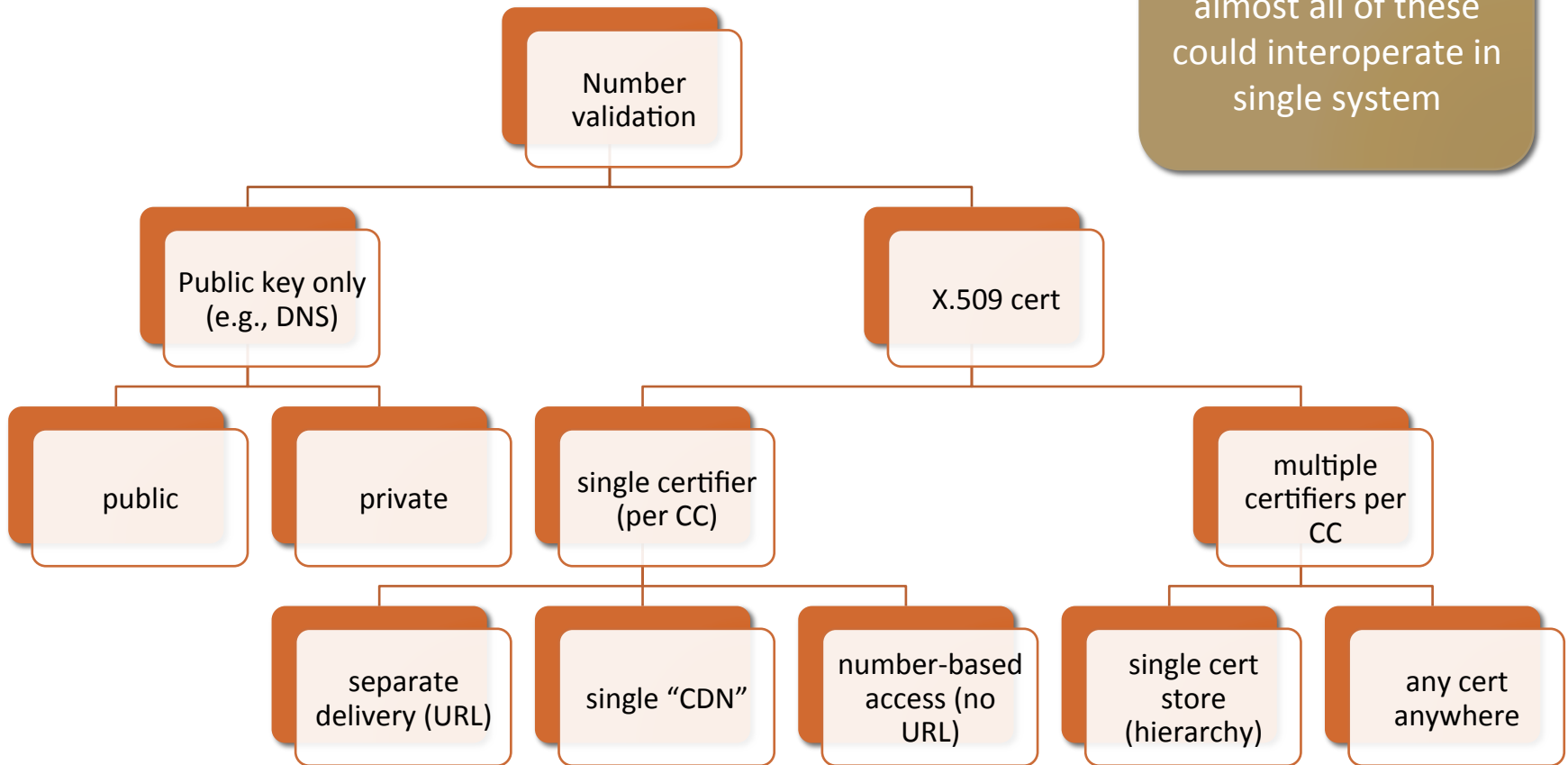
# Porting: confirmation-based

---



# Key management options

almost all of these  
could interoperate in  
single system



# Certificate models

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## *Integrated* with number assignment

- assignment of number includes certificate: “public key X is authorized to use number N”
- issued by number assignment authority (e.g., NPAC), possibly with delegation chain
  - allocation entity → carrier (→ end user)

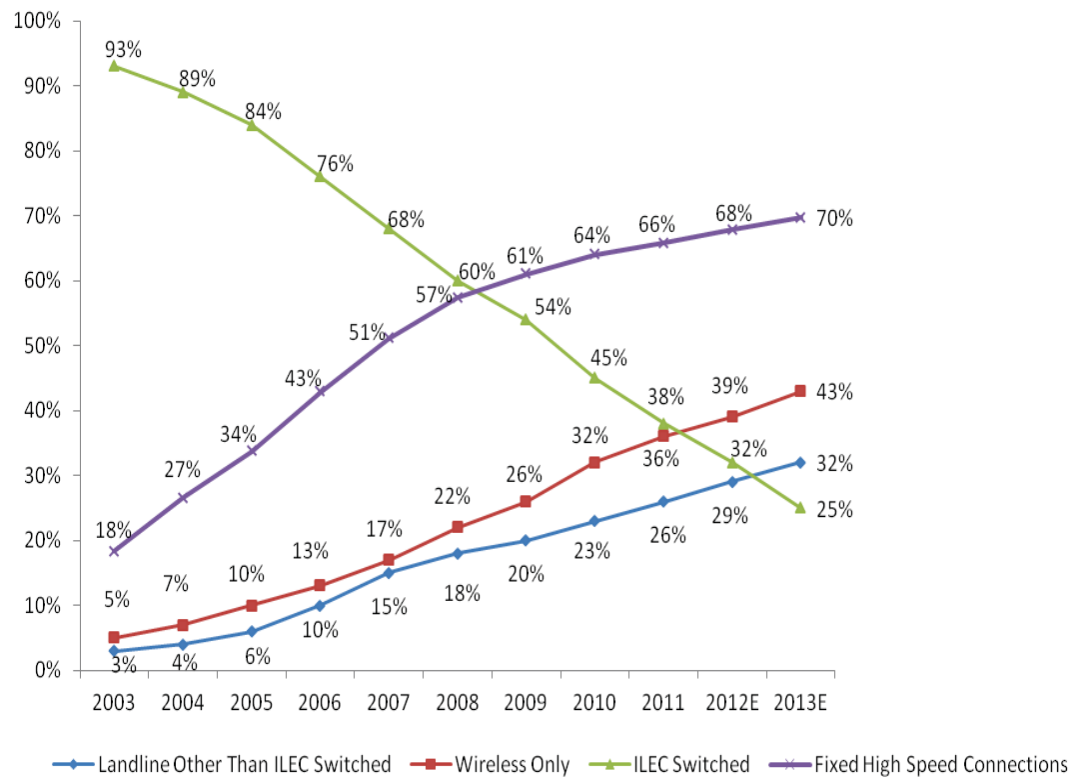
## *separate* proof of ownership

- similar to web domain validation
- e.g., similar to Google voice validation by automated call back
  - “Enter the number you heard in web form”
- Automate by SIP OPTIONS message response?



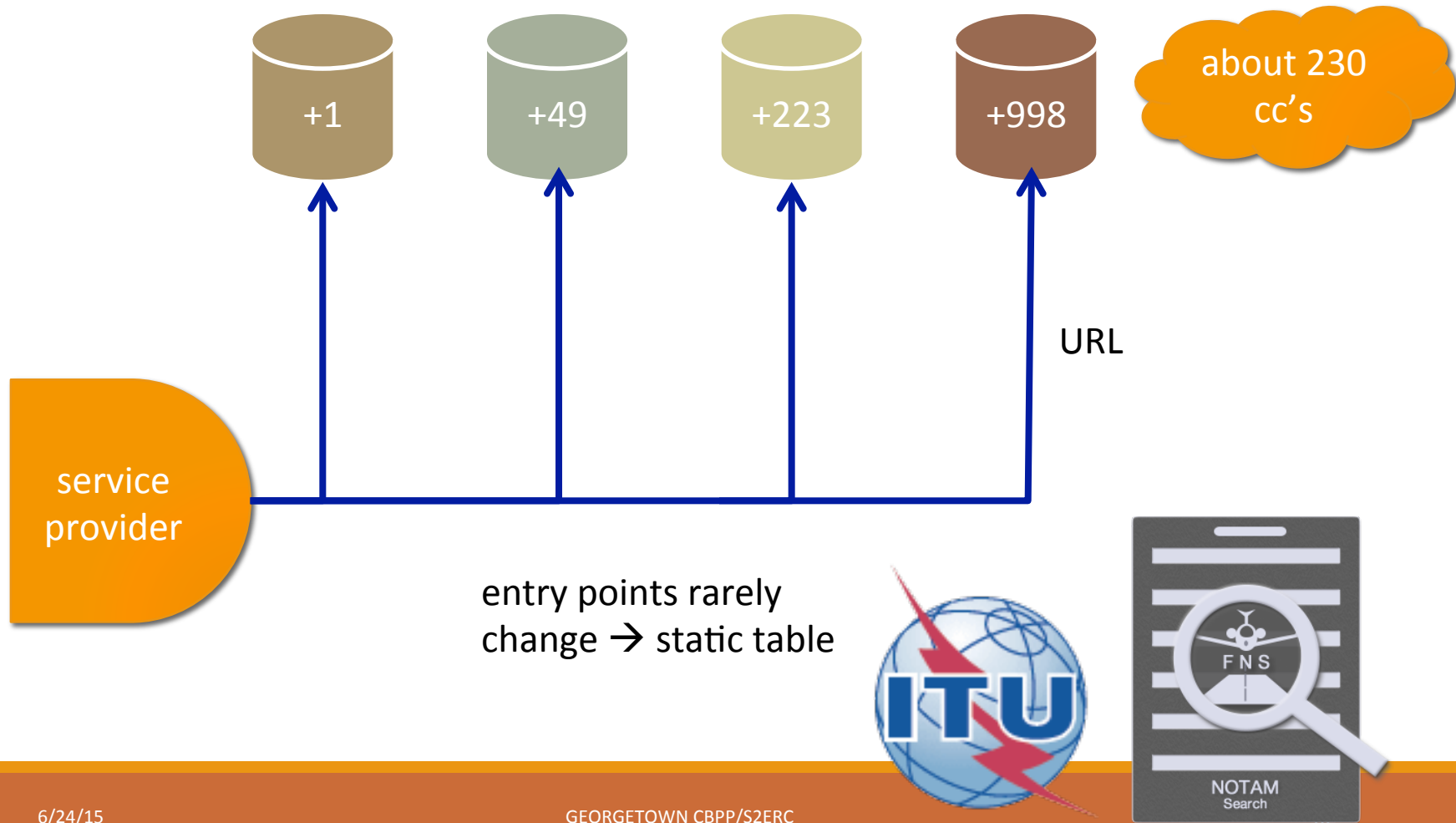
# Residential access

U.S. Household Primary Line and Fixed High Speed Internet Service Penetration and Straight-Line Projections (Percent of Telephone Households)

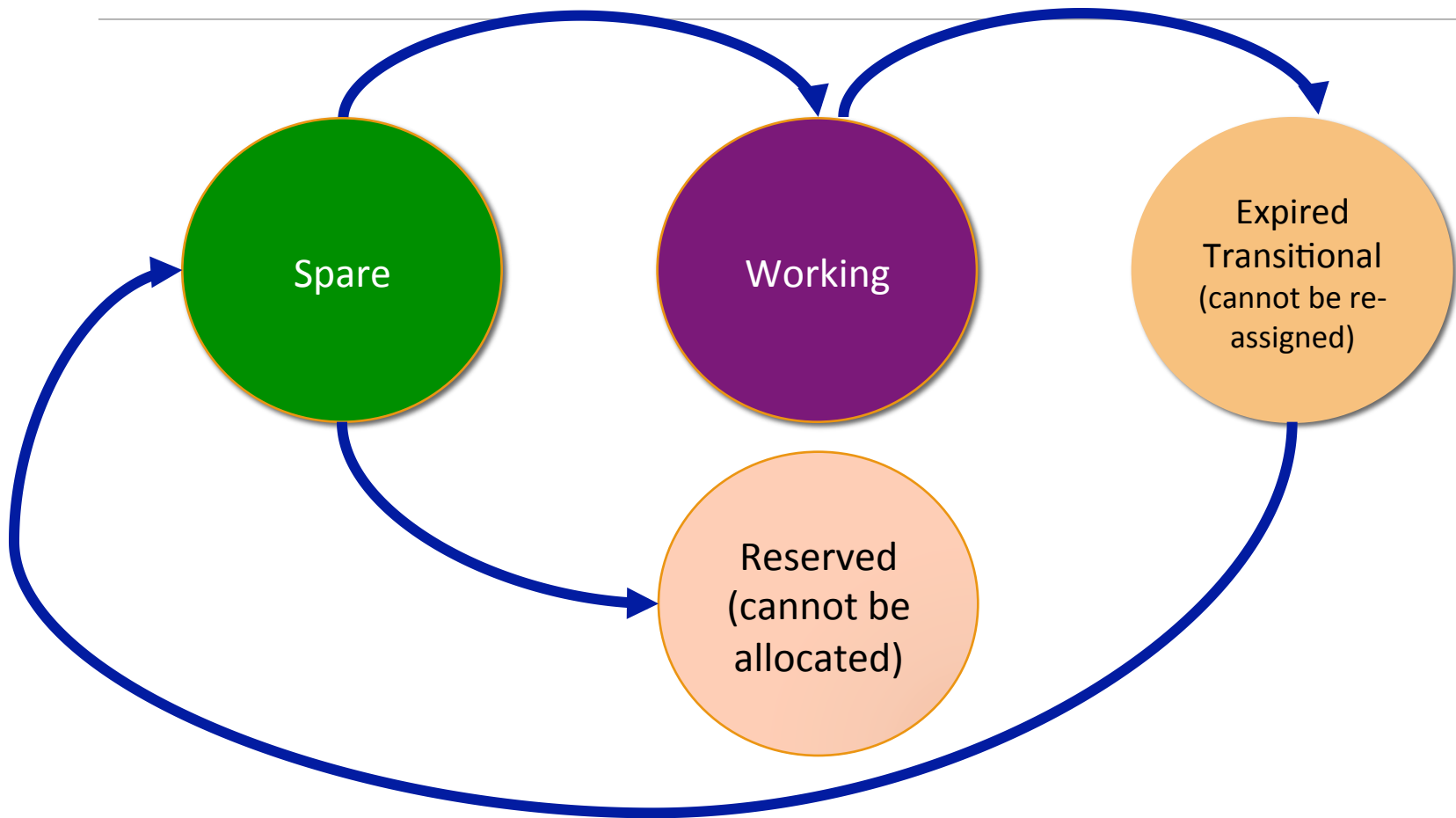


Sources: FCC, CDC, Census, USTelecom Analysis (2008-2013E), and FCC, CDC, NCTA, Financial Reports, CenturyLink Analysis

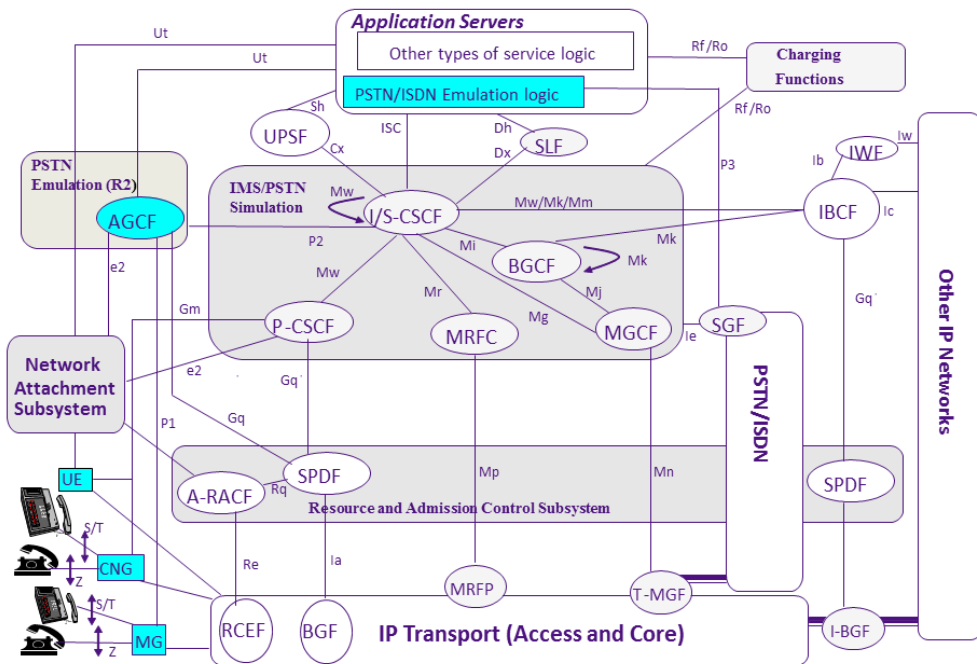
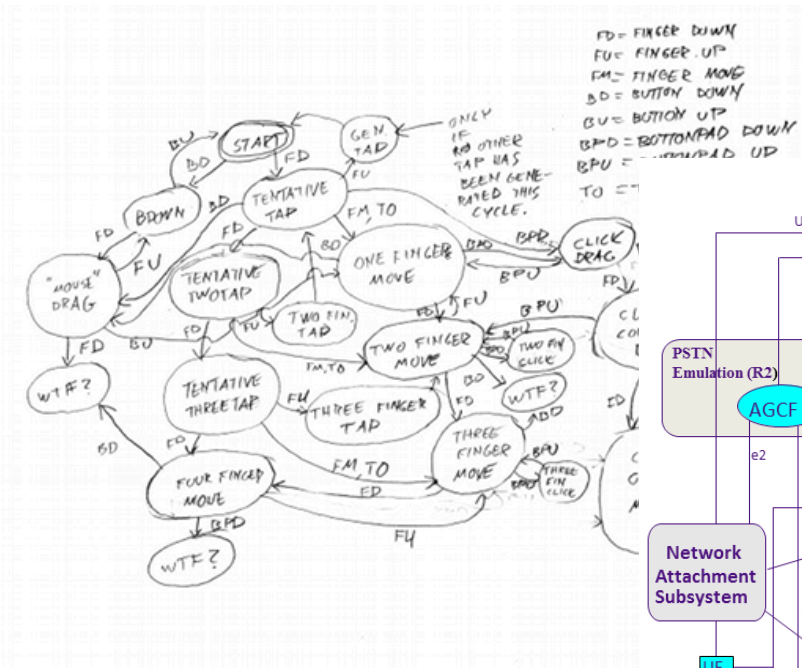
# International routing



# State transitions



# Complexity kills



IMS

# How to ensure correctness

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Distribution of changes → gossiping

- see LoST

Allocation of new numbers & changes → avoid collisions

1. block chain model
2. Paxos, Raft and variants
  - Alice: “may I allocate number/number block X”?
  - Other nodes: “please go ahead, Alice” → quorum
  - Alice: “please change property Y of X to V”
  - Other nodes: “done”

## Recovery

- new or revived replicas can catch up to changes
  - transaction log
  - relatively easy with timestamps (“tell me about changes after T”)

# Robocall prohibitions

---

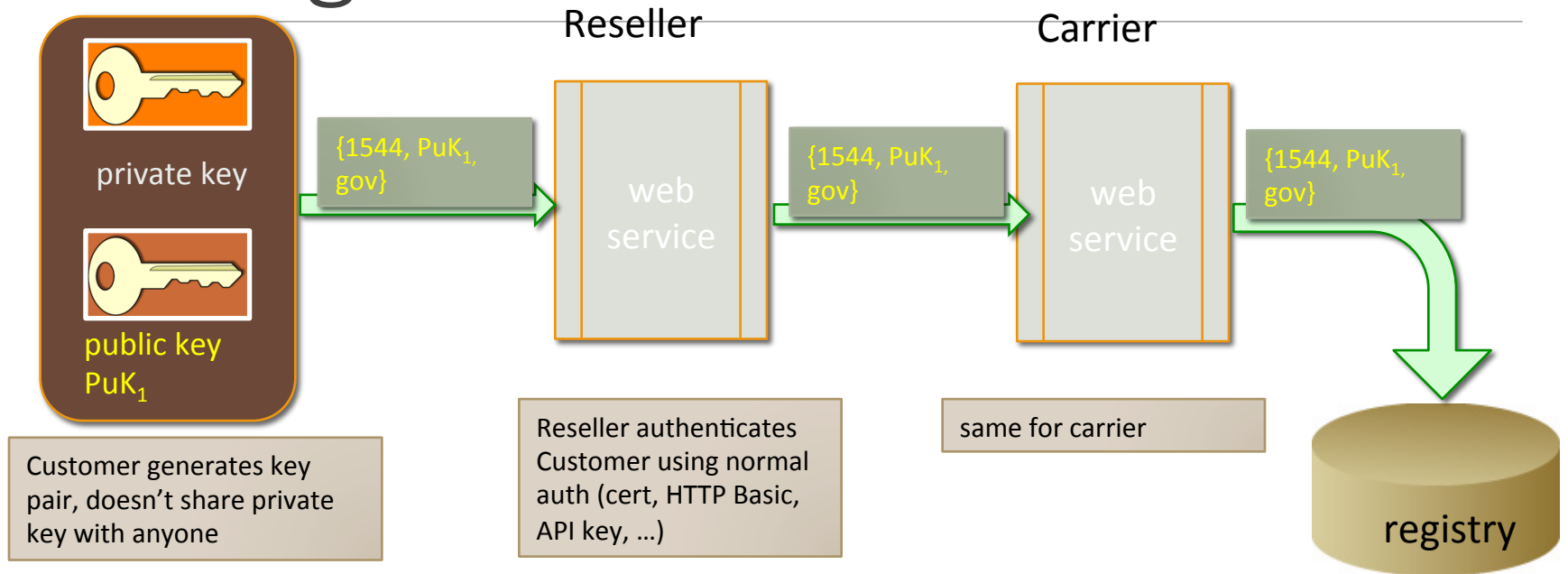
	Wireline residential	Wireline business	Wireless (mobile)
not on DNC	pre-recorded TM	no restriction	pre-recorded non-emergency auto-dialed non-emergency
on DNC	any TM	any TM	any TM pre-recorded non-emergency auto-dialed non-emergency

# How to prevent...

Content	Method	Wireline residential	Wireline business	Wireless (mobile)
Telemarketing	Manual	DNC	DNC	DNC
	Auto-dialed	DNC	DNC	✗
	Pre-recorded	✗	DNC	✗
Informational (including political, charity, polling)	Manual	can't prevent	can't prevent	can't prevent
	Auto-dialed or pre-recorded	opt-out	opt-out	✗
Emergency	Any	permissible	permissible	permissible

Note: DNC does not cover calls from companies with which the customer has an existing business relationship.

# Validation: assignment with delegation



Number	PuK	Prop
202 418 1544	$PuK_1$	.gov
212 939 7042	$PuK_2$	.edu



# Improving caller name reliability

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Textual caller ID used more than number by recipients

Generation of caller name varies:

- Various CNAM/LIDB databases: CPN → name
- Some from caller carrier, some third-party (reduce dip fees)
- Can be generated by third party

Change with VoIP: end-to-end delivery

- basic name, with attribution (“based on business record”, “self-asserted”)
- additional information (“FDIC-registered”, “accredited health care facility”, “registered charity”)

# Generational surprises

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Generation	Expectation	Surprise
2G	better voice quality (“digital!”)	SMS
3G	WAP	web
4G	IMS	YouTube, WhatsApp
5G	IoT (low latency)	?

underestimated cost and fixed-equivalence as drivers

# IMS /VoLTE

## VoLTE: Taking Carriers Beyond Voice

🕒 Mon, 06/06/2011 - 12:43pm

👤 by Maisie Ramsay

✉ [Get today's wireless headlines and news - Sign up now!](#)

Project yourself into the future – let's say mid-2012. It's been about a year and a half since Verizon Wireless first launched its LTE network in December 2010, and after a long wait, the company has finally come out with the first smartphone running voice over LTE (VoLTE) technology.

You go out and buy the device, turning it on the second you have it out of the box. One of the first things you notice: The phone's native voice application isn't limited to just voice. It has an option for video calls, and there's also an option to send multimedia messages, along with presence indicators that show when people on your contact list can participate in a video call.

IMS = It Mostly Speaks  
VoLTE = Voice-Only Later than Expected

## AT&T, Verizon Target VoLTE Interop in 2015, RCS Later

By Doug Mohnney / November 04, 2014

AT&T and Verizon have officially declared they are working on Voice over LTE (VoLTE) connections between their respective networks and customers. VoLTE calls between Verizon and AT&T customers "is expected" in 2015, according to a statement from the companies. And, there's also some Rich Communications Services (RCS) news buried in the text.



The announcement comes as three out of four major U.S. carriers promote LTE networks and a number of countries plan to turn up LTE and VoLTE in the next 15 months. "Interoperability among VoLTE service providers in the United States and around the world will create a better and richer mobile experience for customers," declares Verizon's press release.

## Vodafone Germany announces VoLTE rollout

17 Mar 2015

🇩🇪 Germany

Vodafone Germany claims it has become the first German operator to initiate the rollout of voice-over-LTE (VoLTE), having demonstrated the first live VoLTE call on its network at the CeBIT 2015 technology fair in Hanover. The UK-owned operator says that the technology offers customers an 'unprecedented voice service and telephony experience', ensuring 'crystal clear voice quality, super-fast call set-up and encrypted phone calls' across its LTE network, which currently covers 70% of Germany. Vodafone revealed that it will soon be launching new LTE smartphones for VoLTE, including handsets from manufacturers such as Samsung, Sony and HTC. The announcement follows reports last week that Vodafone plans to introduce both Wi-Fi calling and VoLTE in the UK this summer, following trials of the technologies in laboratory conditions.