Transitioning the PSTN to IP

Henning Schulzrinne

The retirement of the circuit-switched network

* What is happening and why does it matter?
* What are the technical challenges we need to address?
  - reliability & quality
  - public safety ("911", "112")
  - numbering & trustable identifiers
  - universal service
  - service stagnation → beyond voice?
  - copper loops → competition, legacy services
* It's technical + economics + policy

US-centric, but similar elsewhere

FCC's Technology Transition Policy Task Force

- The Task Force's work will be guided by the insight that, technological changes do not alter the FCC's core mission, including protecting consumers, ensuring public safety, enhancing universal service, and preserving competition.
- The Task Force will conduct a data-driven review and provide recommendations to modernize the Commission's policies in a process that *encourages continued investment and innovation* in these new technologies, *empowers and protects consumers*, *promotes competition*, and ensures *network resiliency and reliability*.

The three transitions

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

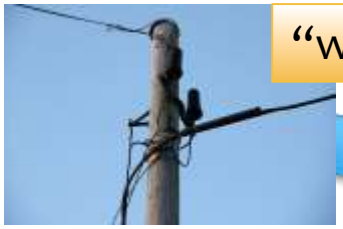
When?

no single transition date!

2013

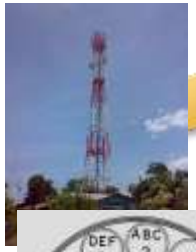
switching (core)

TDM → VoIP



"wireless network is 99% wired"

access



numbering

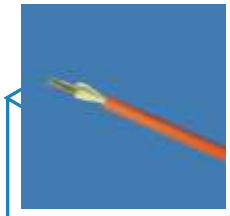
E.164 human-visible → hidden

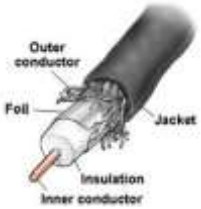
The transition of the PSTN

* User behavior changes
  - more text, less voice
  - video conferencing for personal & business use (telepresence)
  - landline → mobile
  - OTT VoIP (for international calls)
* Core network technology changes
  - IMS
  - SIP trunking
* Access and end system changes
  - large PBX all VoIP
  - voice as app
  - WebRTC

Available access speeds

common now – future capability





100 Mb/s+

20 Mb/s

5 Mb/s

2 Mb/s

1 Mb/s

10 Gb/s

1 Gb/s

10 Mb/s

lte

marginal VOIP

avg. sustained throughput

18%

80%

95%

97%

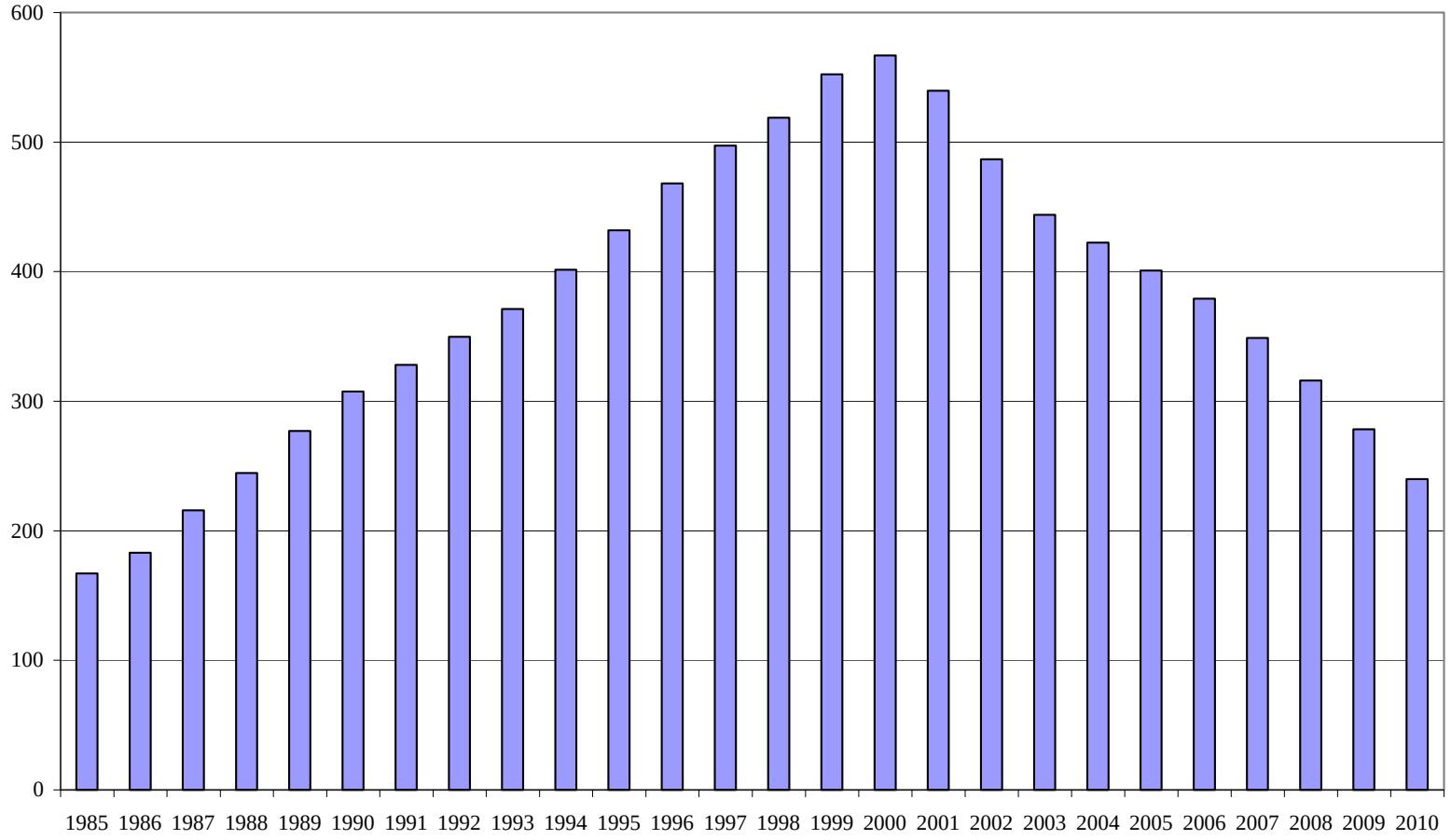
100%

99% by 2023?

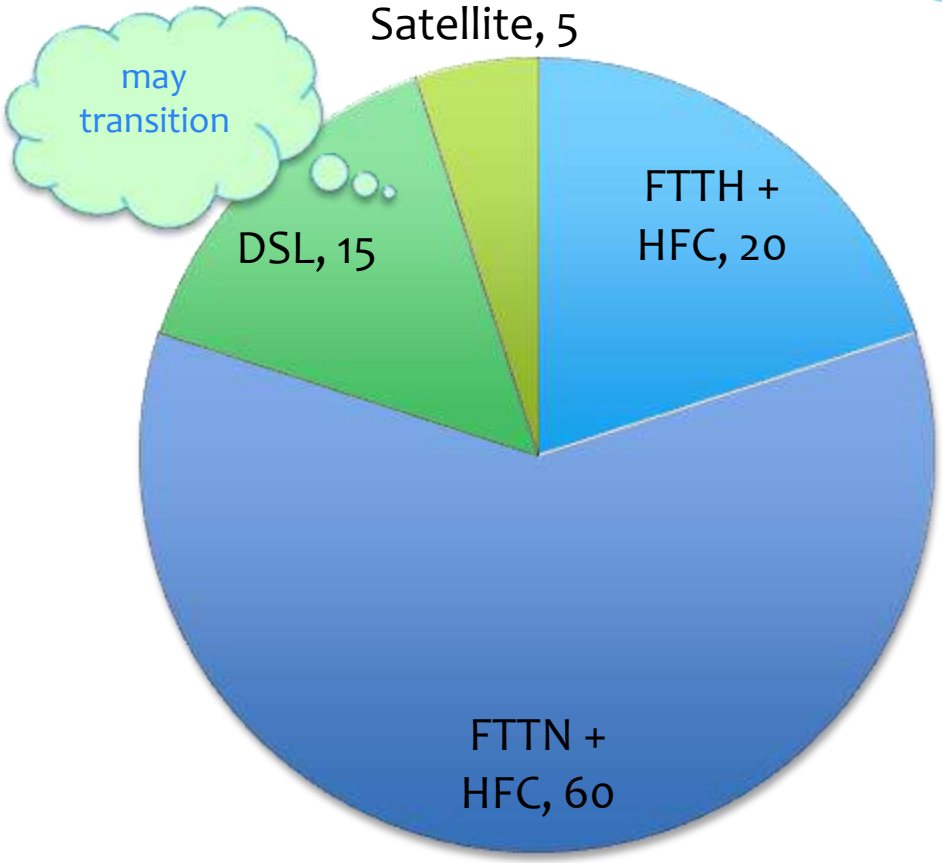
of households

Interstate switched access minutes

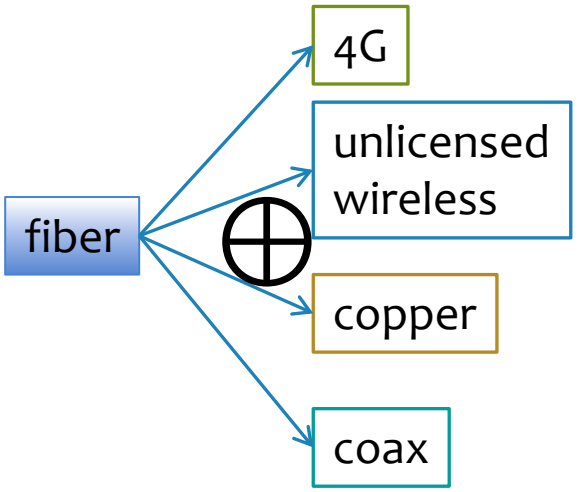
Chart 5.1
Interstate Switched Access Minutes of Use for Incumbent Local Exchange Carriers
(in Billions)



Access transitions (US)



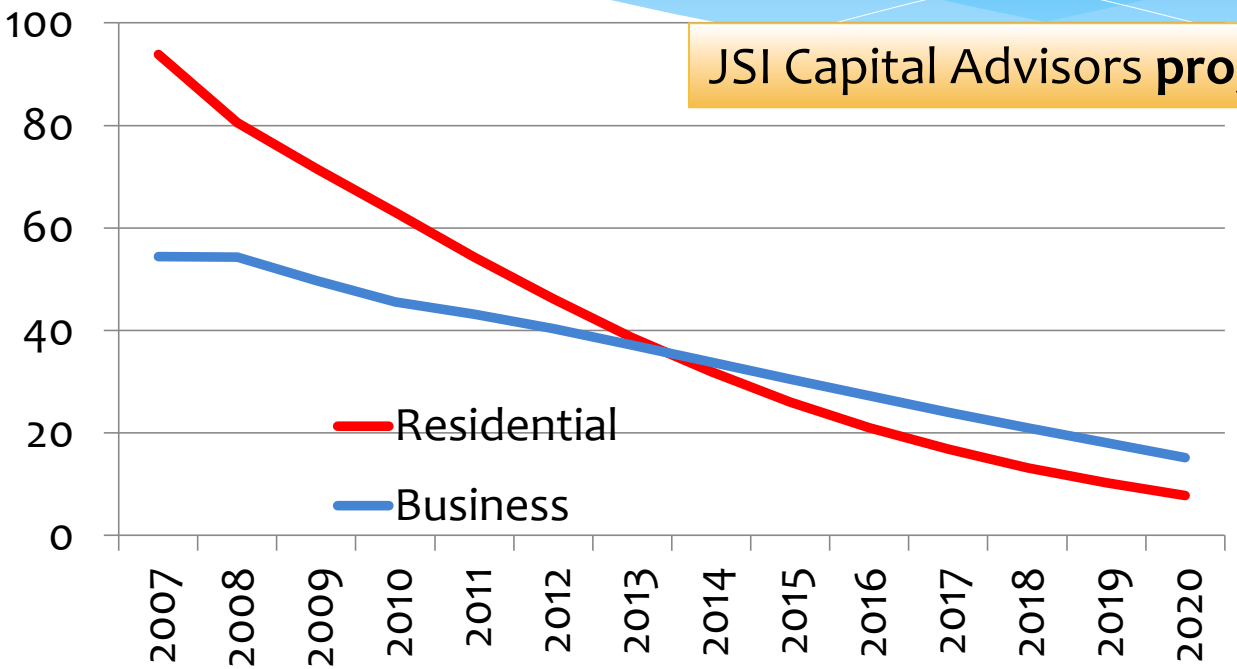
networks go hybrid:



last 500-3000 ft

Lines are disappearing, but maintenance costs are constant

voice only
(DSL: 20 M)



JSI Capital Advisors **projection**

per-line monthly maintenance cost

$2.72

$17.57

voice revenue/line:
$50

dis

Switches are ageing

Nortel DMS-100

1979

http://www.phworld.org/switch/ntess.htm

What are some of the "keeper" attributes?

* Universality
  - *reachability* → global numbering & interconnection
  - *media* → HD audio, video, text
  - *availability* → universal service regardless of
    * geography
    * income
    * disability
  - *affordability* → service competition + affordable standalone broadband
* Public safety
  - citizen-to-authority: emergency services (911)
  - authority-to-citizen: alerting
  - law enforcement
  - survivable (facilities redundancy, power outages)
* Quality
  - media (voice + …) quality
  - assured identity: telephone numbers
  - assured privacy (CPNI)
  - accountable reliability

initial list – not exhaustive

Universal service

One Policy, One System, Universal Service

T. Vail (1907)

For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States, without discrimination on the basis of race, color, religion, national origin, or sex, a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, for the purpose of promoting safety of life and property through the use of wire and radio communications, … (47 USC § 151, 1934)

* Eligible Telecommunications Carriers
* Carrier of Last Resort (COLR)
* *Universal Service Fund*

Numbers: Disappearance of the old constraints

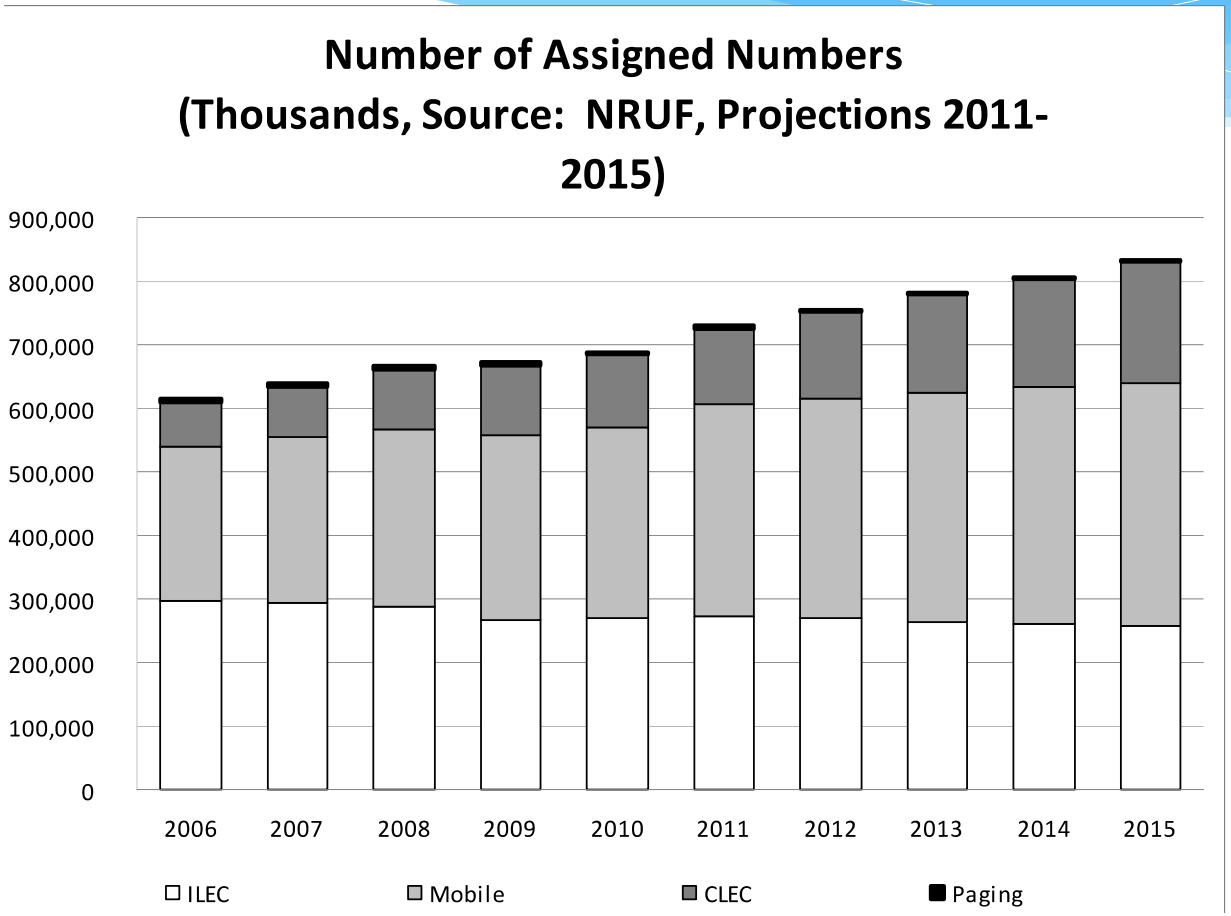
Communication identifiers

Property	URL owned	URL provider	E.164	Service-specific
Example	alice@smith.name sip:alice@smith.name	alice@gmail.com 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
Privacy	Depends on name chosen (pseudonym)	Depends on naming scheme	mostly	Depends on provider "real name" policy

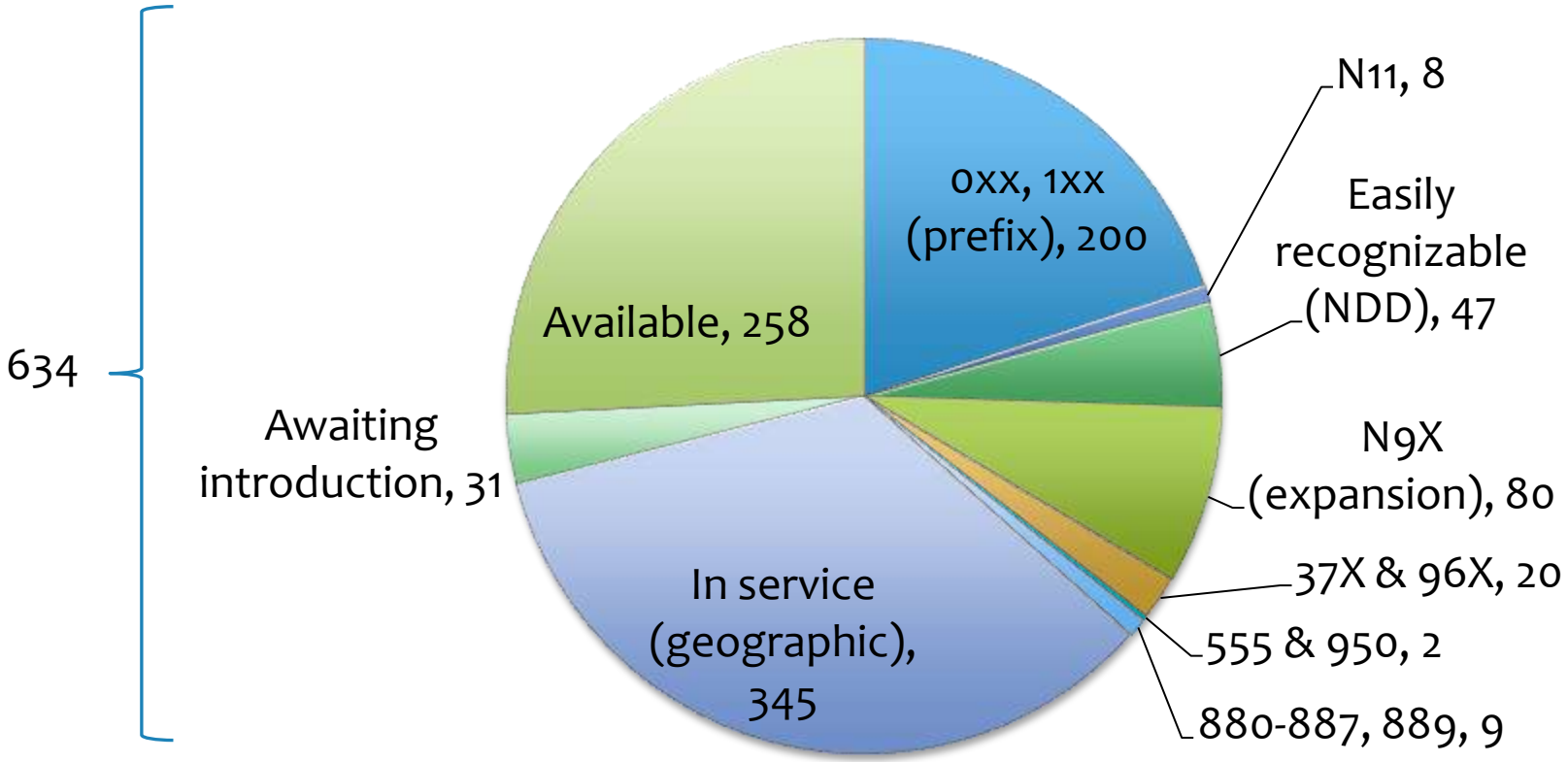
Numbers vs. DNS & IP addresses

	Phone #	DNS	IP address
Role	**identifier** + locator	identifier	**locator** (+ identifier)
Country-specific	mostly	optional	no
# of devices / name	1 (except Google Voice)	any	1 (interface)
# names /device	1 for mobile	any	any
controlled by	carrier, but portability unclear (800#) and geo. limited	any entity, with trademark restrictions	any entity (ISP, organization)
who can obtain?	geographically-constrained, currently carrier only	varies (e.g., .edu & .mil, vs. .de)	enterprise, carrier
porting	complex, often manual; wireless-to-wireline may not work	about one hour (DNS cache)	if entity has been assigned PIAs
delegation	companies (number range)	anybody	subnets
identity information	carrier (OCN), billing name only → LERG, LIDB	WHOIS data (unverified)	RPKI, whois

Number usage



Area codes (NPAs)



FCC "Numbering" order April 2013

* NPRM: allow interconnected VoIP providers to obtain numbers
* R&O: waiver petitioners can get small pool of numbers directly from NANPA or PA
* NOI: geographic assignment of numbers still relevant?
* Doesn't directly address databases

Phone numbers for machines?

< 2010

212 555 1212 →

500 123 4567
(and geographic numbers)

OnStar by GM

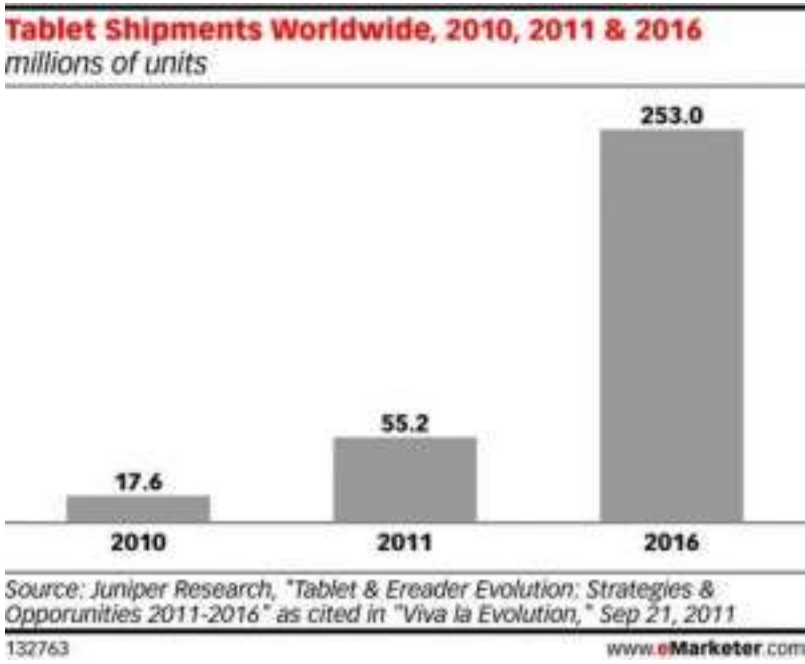
500 123 4567
533, 544 →

12% of adults

5 mio.

311,000

64 mio.



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

10 billion available

see Tom McGarry, Neustar

Future numbers

* Should numbers be treated as names?
  - see “Identifier-Locator split”
  - “multi-homing”
* Should numbers have a geographic component?
  - Is this part of a region’s cultural identity?

Phone numbers: hoarding

- How to prevent hoarding?
  - By pricing
    - DNS-like prices ($6.69 - $10.69/year for .com)
      - takes $100M to buy up (212)…
      - 1626: 60 guilders
    - e.g., USF contribution proposals
      - $8B/year, 750 M numbers → $10.60/year
      - but significant trade-offs
  - By demonstrated need
    - see IP address assignment
    - 1k blocks
    - difficult to scale to individuals

Philadelphia telecom hoarding toll-free phone numbers

By McClatchy Tribune Newspapers
Posted today at 12:34 p.m.

A small Philadelphia telecommunications company with close ties to an adult-entertainment business has amassed control of more than 1 million toll-free numbers, according to industry sources and a published report.

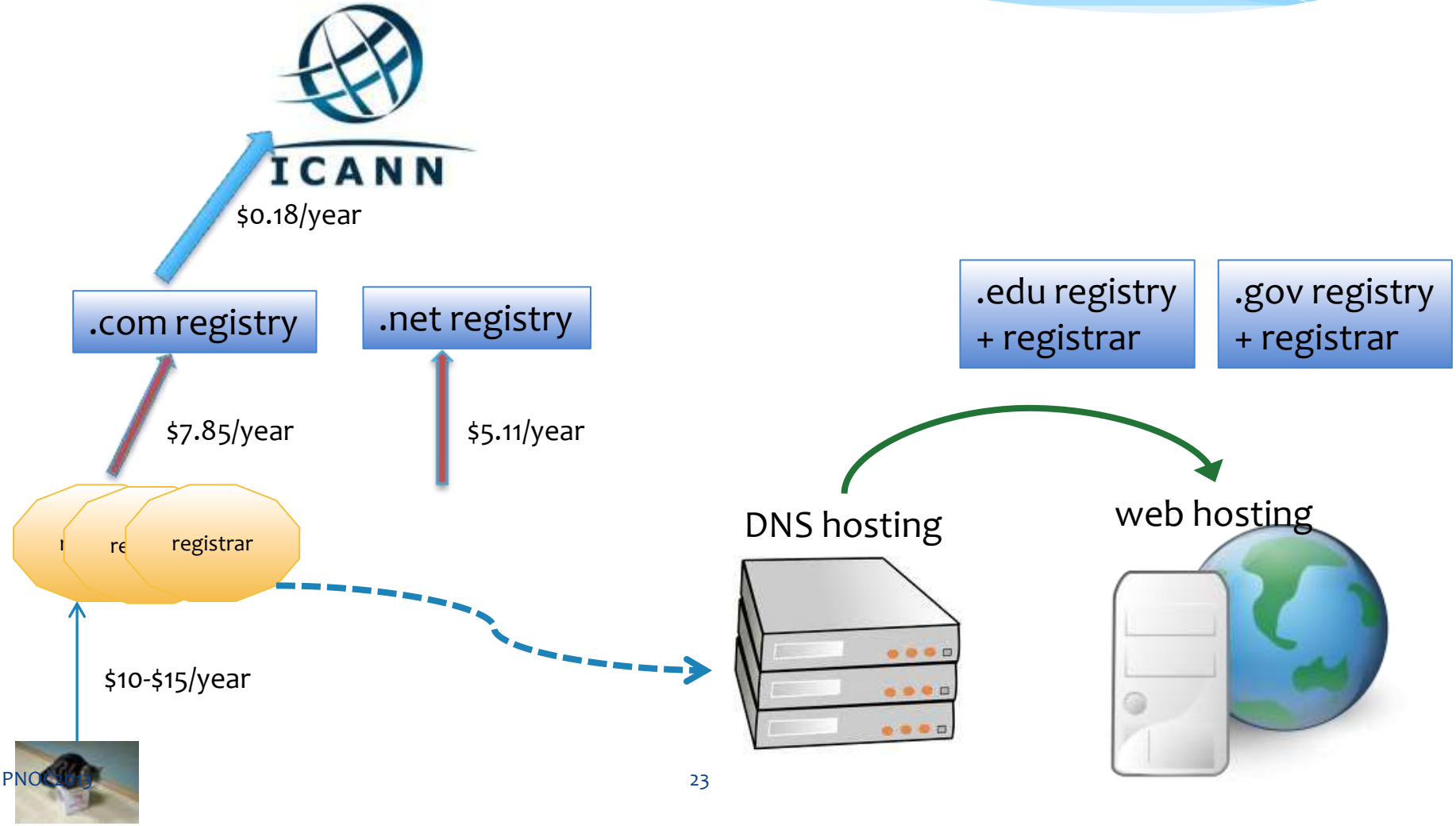
The toll-free numbers, including 1-800-CHICAGO or 1-800-YOUR-PHILLIES, are used mostly to redirect callers to phone-sex services, the industry observers say.

[redacted] Inc.'s aggressive acquisition of a massive quantity of toll-free numbers has been controversial in the industry because it has left fewer available for other business purposes.

Though there is a public perception that the toll-free business has waned with the proliferation of interactive technologies, officials say the industry continues to grow, with about 30 million toll-free numbers in use.

100 million .COM

Internet identifier management: Domain name registration



Caller ID spoofing

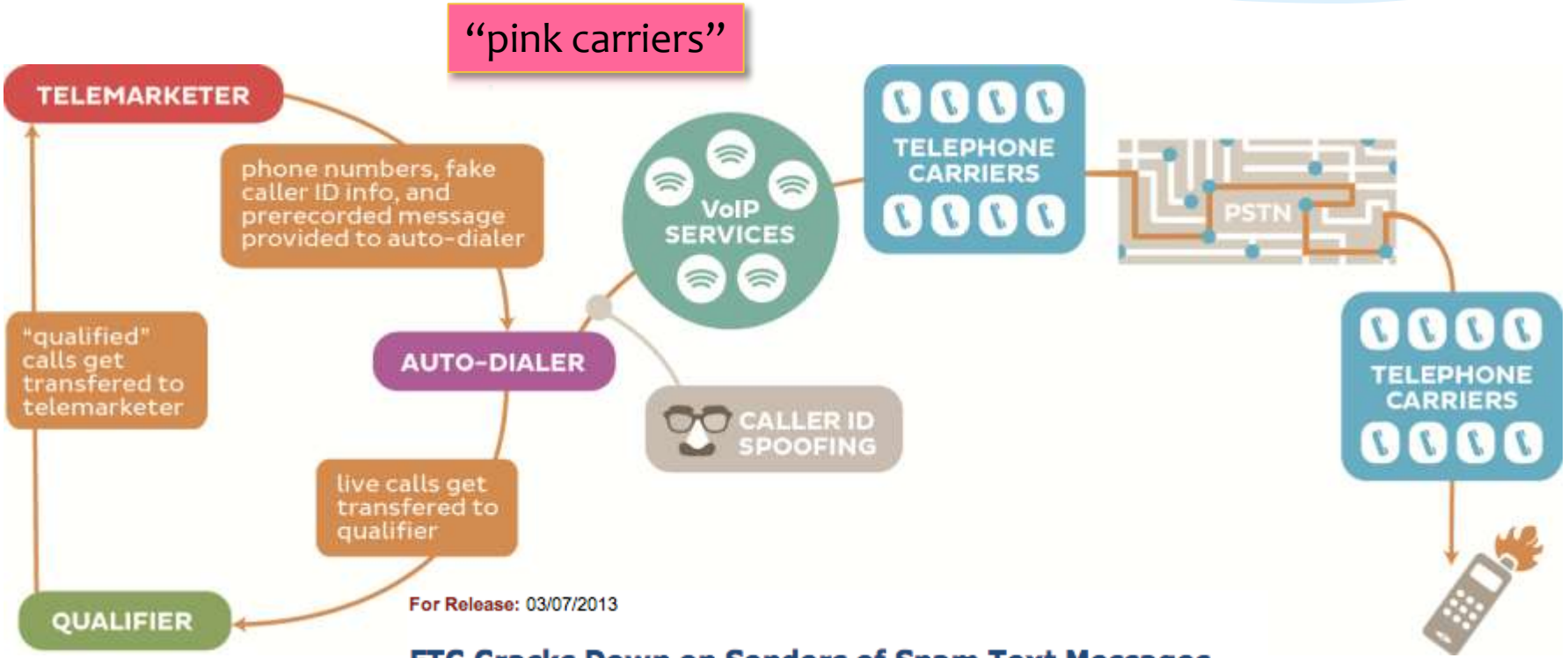
* Easily available on (SIP) trunks – can be legitimate
* Used for vishing, robocalling, swatting, anonymity breaking, …
* Caller ID Act of 2009: *Prohibit any person or entity from transmitting misleading or inaccurate caller ID information with the intent to defraud, cause harm, or wrongfully obtain anything of value.*
* Also: phantom traffic rules

Caller ID spoofing

A. Panagia, AT&T

* enhances theft and sale of customer information through pretexting
* harass and intimidate (bomb threats, disconnecting services)
* enables identity theft and theft of services
* compromises and can give access to voice mail boxes
* can result in free calls over toll free dial-around services
* facilitates identification of the name (CNAM) for unlisted numbers
* activate stolen credit cards
* causes incorrect billing because the jurisdiction is incorrect
* impairs assistance to law enforcement in criminal and anti-terrorist investigations
* *FCC rules address caller ID spoofing, but enforcement challenging*

Robocalling



For Release: 03/07/2013

FTC Cracks Down on Senders of Spam Text Messages Promoting "Free" Gift Cards

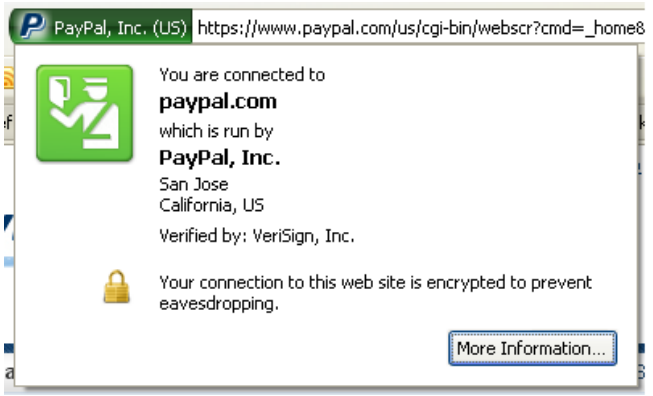
Defendants Were Responsible for More than 180 Million Spam Text Messages

Security (trustworthiness)

* Practically, mostly about *identity*, not *content*
* Old model: "trust us, we're the phone company"
* Need cryptographically-verifiable information
  - Is the caller authorized to use this number?
    * not necessarily "ownership"
    * RFC 4474 (SIP identity) doesn't deal (well) with phone numbers
    * Must also support SS7 transport
  - Has the caller ID name been verified?
    * cf. TLS

Who assures identity?

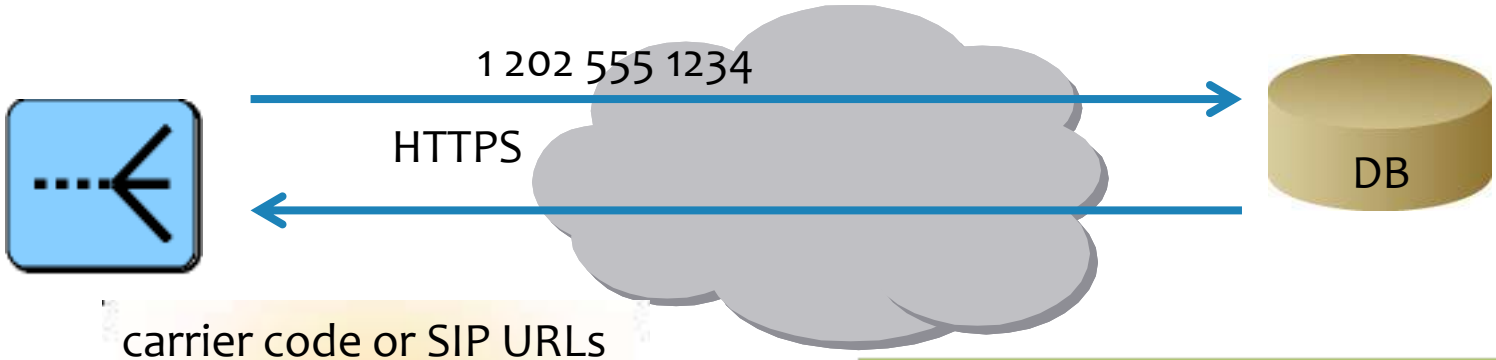
* Web:
  - plain-text → rely on DNS, path integrity
    * requires on-path intercept
  - X.509 certificate: email ownership
    * no attributes
  - EV ("green") certificate
* PSTN
  - caller ID
  - display name: CNAM database, based on caller ID



Strawman "Public" PSTN database

e.g., IETF TERQ effort

* Now: LIDB & CNAM, LERG, LARG, CSARG, NNAG, SRDB, SMS/800 (toll free), do-not-call, …
* Future:



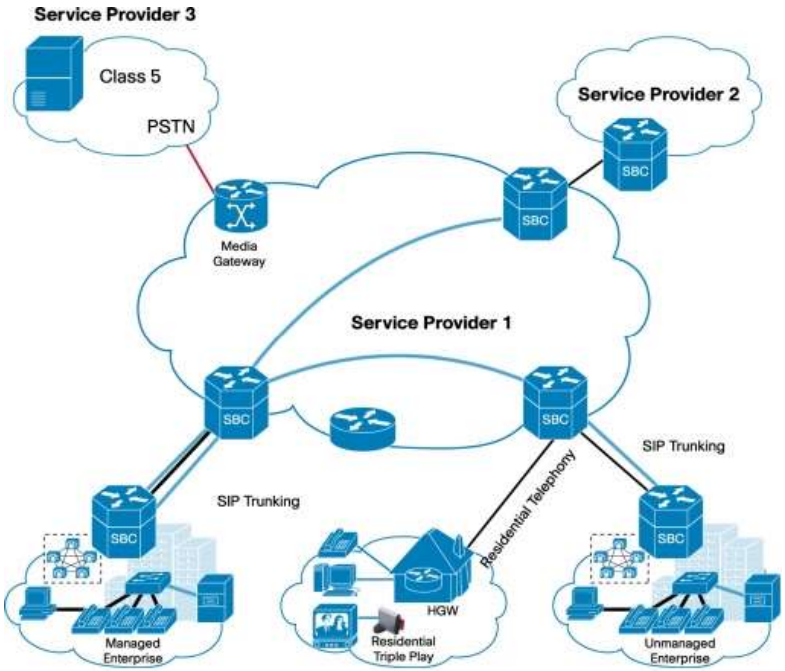
carrier code or SIP URLs
type of service (800, …)
owner
public key
…

extensible set of fields
multiple interfaces (legacy emulation)
multiple providers

VoIP interconnection, public safety, universal access

VoIP Interconnection

* "VoIP interconnection" ≠ IP peering
* Are there technical stumbling blocks?
  - SIP features?
  - Media codecs & conversion?
* Separation application layer & transport
* $0.001 / minute for IP transport ($0.10/GB) → location not relevant



Cisco

Interconnection

* PSTN: general interconnection duty
  - requires physical TDM trunks and switch ports
* VoIP:
  - VPN-like arrangements
  - MPLS
  - general Internet
  - may require fewer points-of-interconnect
  - only relatively small number of IXPs
  - transition to symmetric billing (cellular minutes, flat-rate) rather than caller-pays

Public Safety (NG911 & NG112)

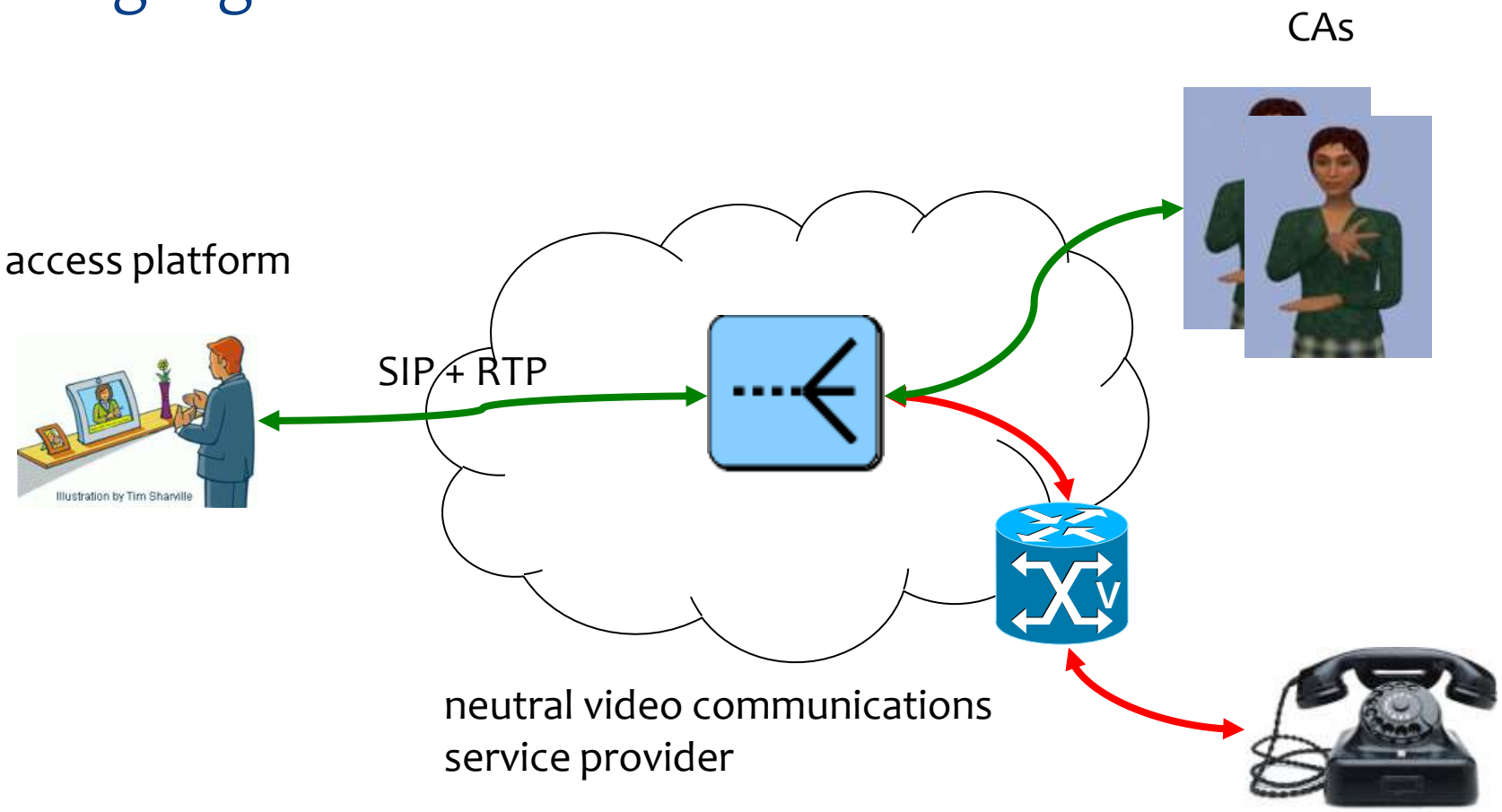
* Transition to NG911 & NG112 underway
  - NGxxx = all-IP (SIP + RTP) emergency calling
* Key issues:
  - *Indoor location* for wireless
    * location accuracy of 50/150m may not be sufficient
    * need apartment-level accuracy, including floor
    * civic (Apt. #800, 1050 N. Stuart), not geo
    * beacon-based technology unlikely to suffice
  - Cost, scaling and transition

More than point-to-point voice

* VoIP = Voice + Video + Vords (text)
  - → Real-time communication as base-level service?
* Accommodate new media codecs (e.g., AMR)
* See also "advanced communication systems" in U.S. Communications and Video Accessibility Act (CVAA)
* Just point-to-point? or multipoint?
* Services beyond call forwarding → web API model
  - e.g., for robocall prevention

Video relay service (VRS) reform

* Serves about 125k-200k people who use sign language



Reliability

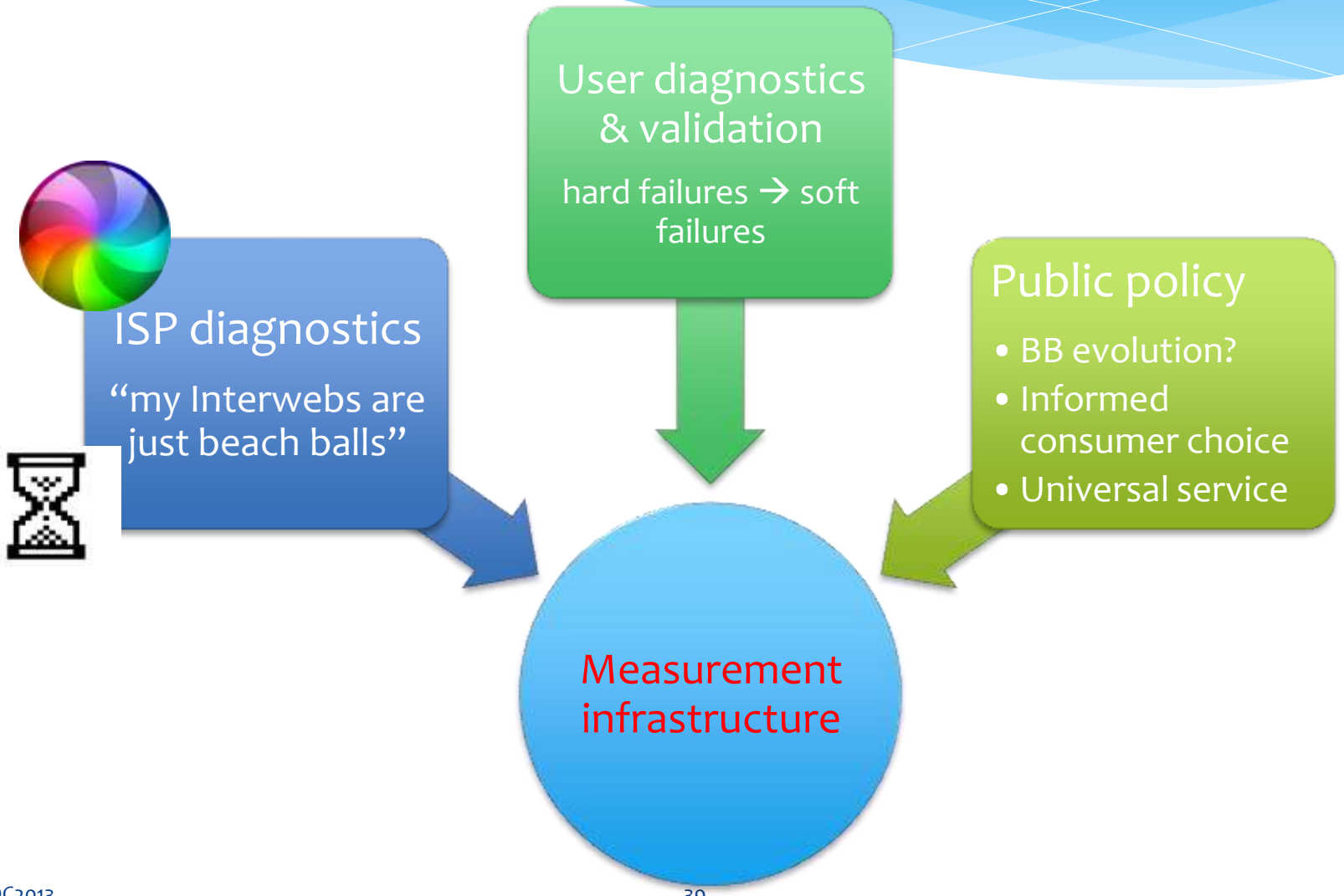
* 5 nines → 5 minutes/year unavailable
* How do we measure reliability & QoS?
  - E.g., FCC *Measuring Broadband America* project?
  - → IETF LMAP
* Can we improve power robustness?
  - Circuit-switched: -48V @ 20-50 mA (~ 1 W)
  - e.g., DOCSIS modem consumes ~7W (idle)
  - Li-Ion battery = 2.5 Wh/$ ➔ 3$/hour of standby time
* Can we simplify multihoming to make new PSTN more reliable than old?
  - e.g., cable + 4G

QoS measurements

FCC measurement history

- FCC has acquired and analyze data on legacy PSTN
- More recent and evolving broadband interest
  - Section 706 of 1996 Telecommunications Act → annual report on availability of advanced telecommunications services to all Americans
    - Resulted in information on deployment of broadband technology ("Form 477")
    - but not its performance
  - FCC's National Broadband Plan – March 2010
    - Proposed performance measurements of broadband services delivered to consumer households
    - Work plan evolved from recommendations of National Broadband Plan

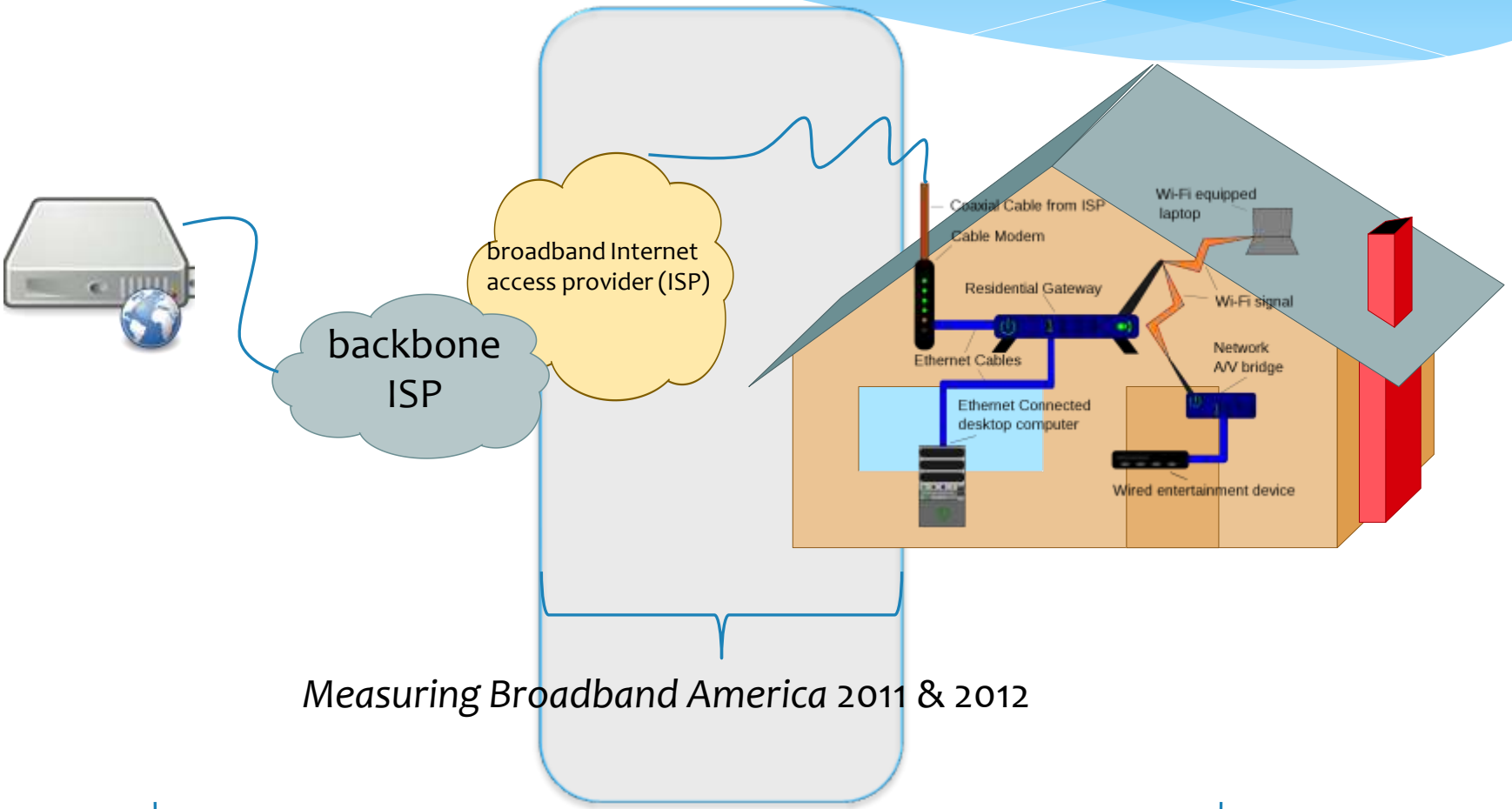
The role of network measurements



Principles

* The FCC Measuring Broadband America program is based on principles of openness, transparency and partnership with diverse stakeholders.
* We are committed to:
  - Ensuring that commonly accepted principles of *scientific research*, *good engineering practices*, and *transparency* guide the program;
  - Encouraging *collaboration* of industry, academia and government;
  - *Publishing the comprehensive technical methodology* used to collect the data, including the source code for the tests as open source;
  - *Releasing data* used to produce each report coincident with the report's release, and releasing all data for each collection cycle within one year of collection.

Measurement architecture



Measuring Broadband America 2011 & 2012

Measuring Broadband America future?

The MBA project - logistics

* Enlisted cooperation:
  - 13 ISPs covering 86% of US population
  - vendors, trade groups, universities and consumer groups
* Reached agreement reached on what to measure and how to measure it
* Enrolled roughly 9,000 consumers as participants
  - 6,800 (7,782) active during March 2011 (April 2012)
  - A total of 9,000 active over the data collection period

What was measured

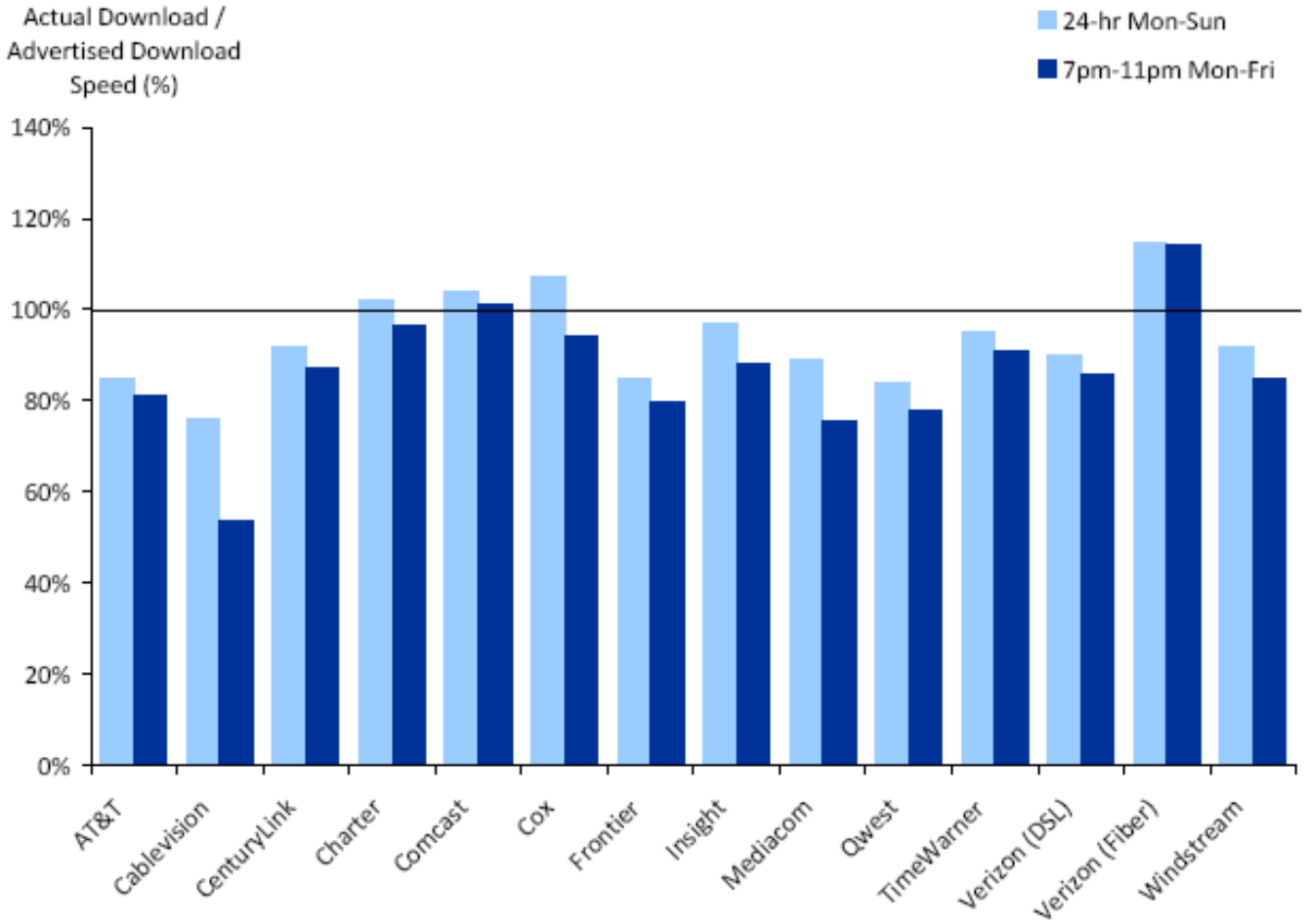
Sustained Download	Burst Download
Sustained Upload	Burst Upload
Web Browsing Download	UDP Latency
UDP Packet Loss	Video Streaming Measure
VoIP Measure	DNS Resolution
DNS Failures	ICMP Latency
ICMP Packet Loss	Latency Under Load
Total Bytes Downloaded	Total Bytes Uploaded

What was released

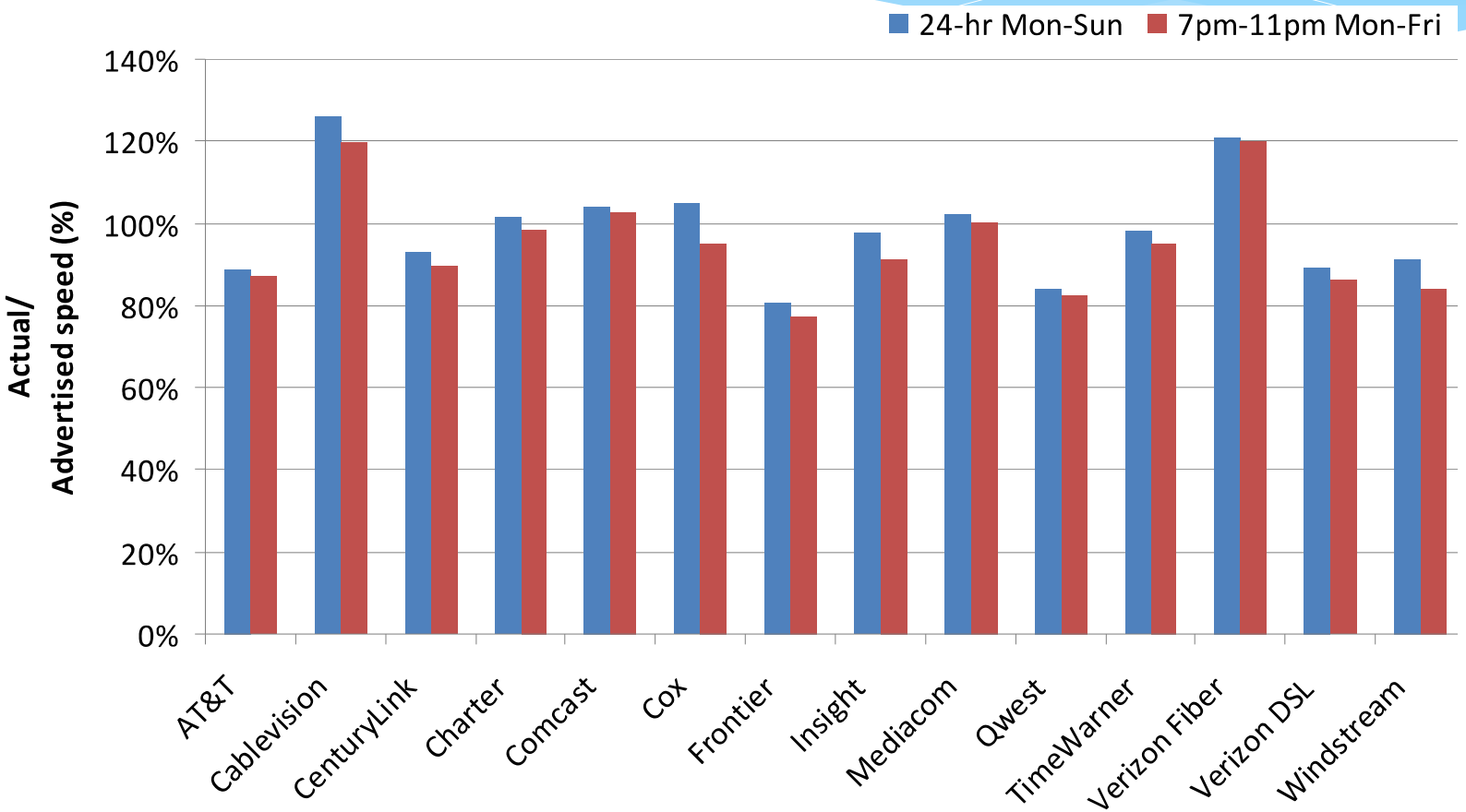
* *Measuring Broadband America* reports
  - Main section describing conclusions and major results
  - Technical appendix describing tests and survey methodology
* Spreadsheet providing standard statistical measures of all tests for all ISPs and speed tiers measured
* Report period data set with 4B data elements from over 100M tests
  - Data set presented as used with anomalies removed
  - Documentation provided on how data set was processed
  - All data, as recorded
* Geocoded data on test points recently released
* Information available at http://www.fcc.gov/measuring-broadband-america

2011: Most ISPs deliver close to advertised during peak hours

Chart 1: Average peak period and 24-hour sustained download speeds as a percentage of advertised, by provider

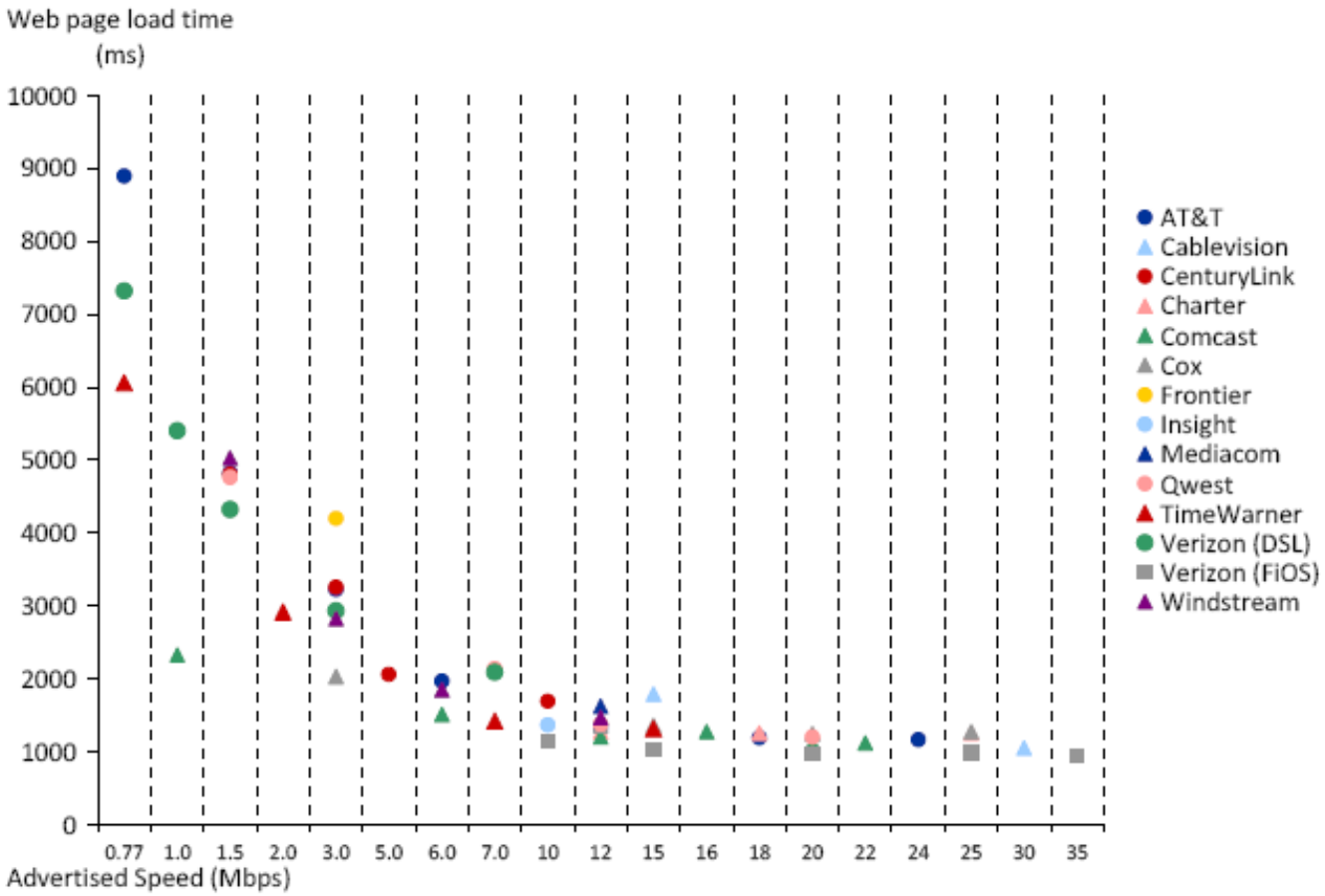


2012: You improve what you measure…



Web page downloading

Chart 10: Web loading time by advertised speed, by technology



The Internet is not a series of (fixed-width) tubes

* Some cable companies advertise burst speed
  - Quota based technique providing temporary speed increase of < 15 seconds
    * Also affected by other household activity
  - Can't be applied generally to DSL where sync rate often limiting factor
  - Marginal value to fiber where each subscriber has potentially available 37 Mb/s to 75 Mb/s provisioned bandwidth
  - → Links are no longer constant-size bit pipes
* Measured both burst and sustained speed

Conclusion

* Three simultaneous technology transitions:
  - copper → fiber, wired → wireless, circuit → packet
* But no cut-over date
* Need to "grow up" quickly
  - no more second network for reporting & fixing things
  - universal service → Internet access for everyone
  - single network → suitable for demanding services
  - life-and-safety network
  - measure all aspects of performance