Evolution of Access Technologies

FCC Technology Transitions Policy Task Force Workshop

David Eckard – CTO Fixed Networks Division

March 18th, 2013

GOVERNMENTS RECOGNIZE THE VALUE OF BROADBAND

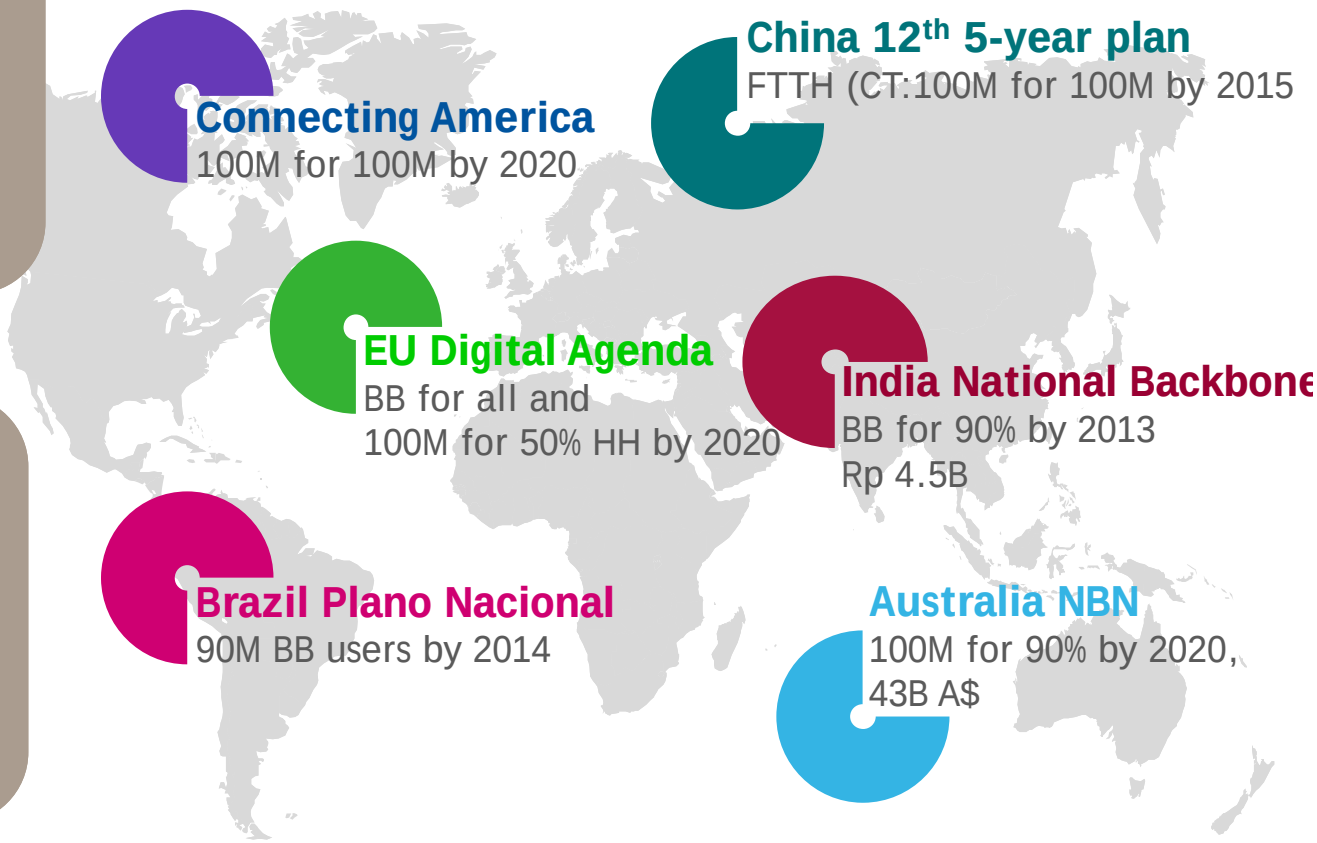
...AND ENCOURAGING THE EXECUTION

Socio-economic benefits:

- Job creation
- Close the Digital Divide
- Location Independence
- Productivity

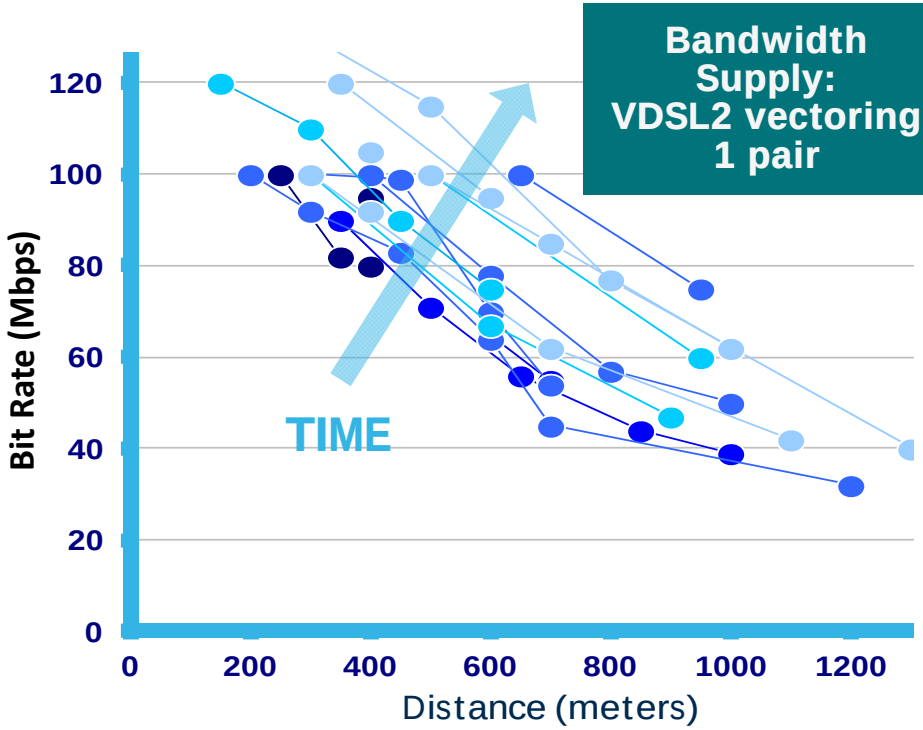
Cost savings:

- Health
- Education
- Transportation
- Energy Conservation

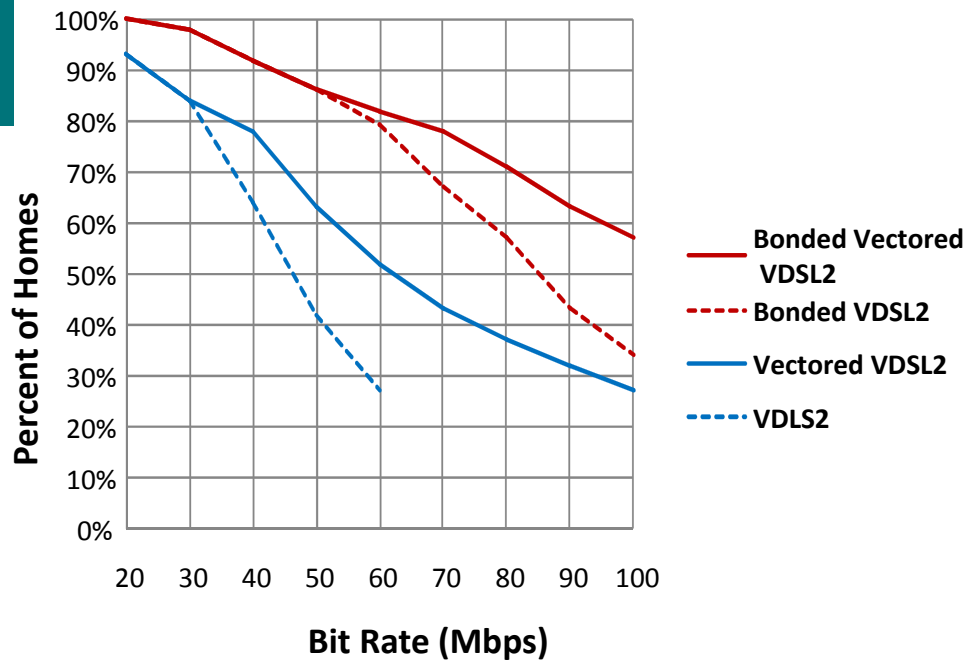


Alcatel·Lucent

Can vectored VDSL2 meet future bandwidth demand?

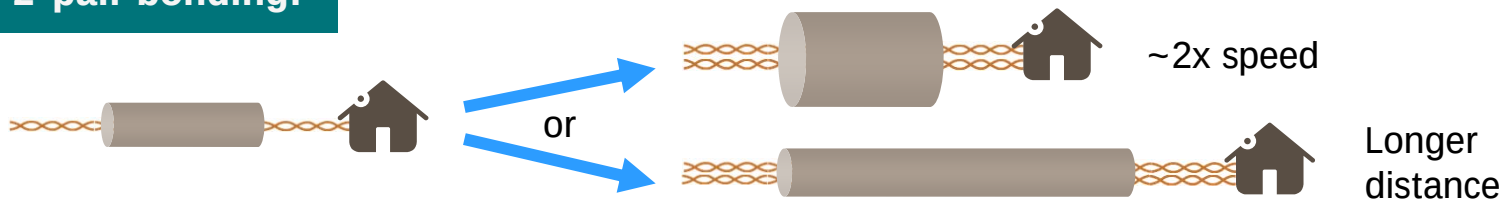


Measured Performance of Vectoring



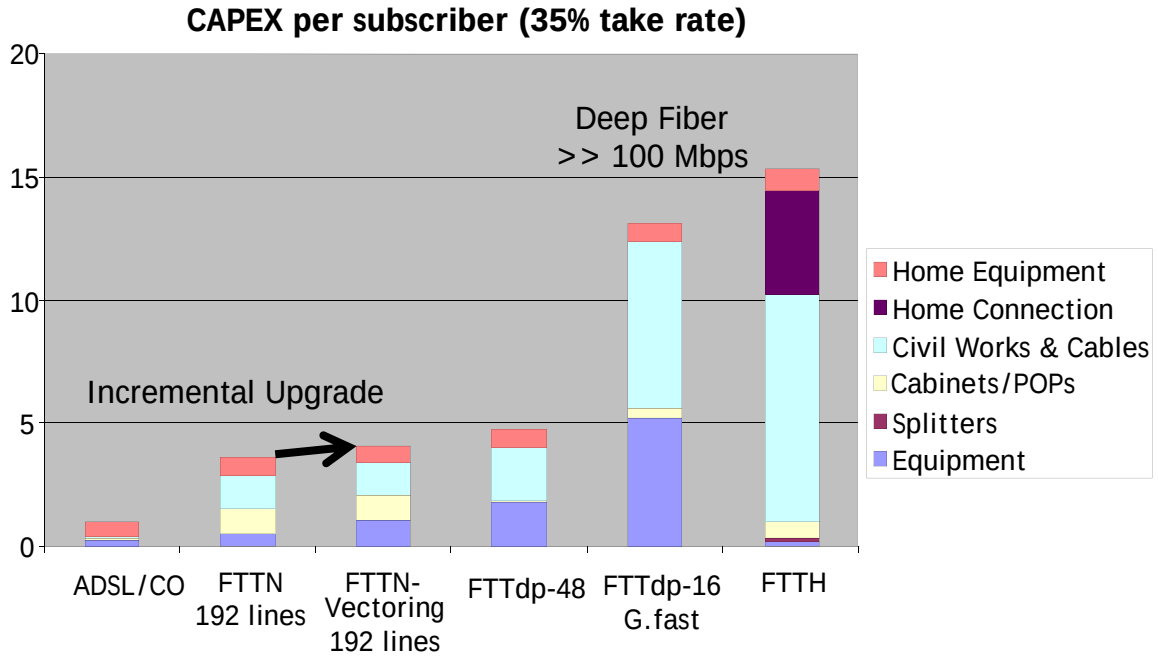
Service vs Coverage for representative NAR FTTN Serving Area

Add 2-pair bonding:



Meeting the National Broadband Plan

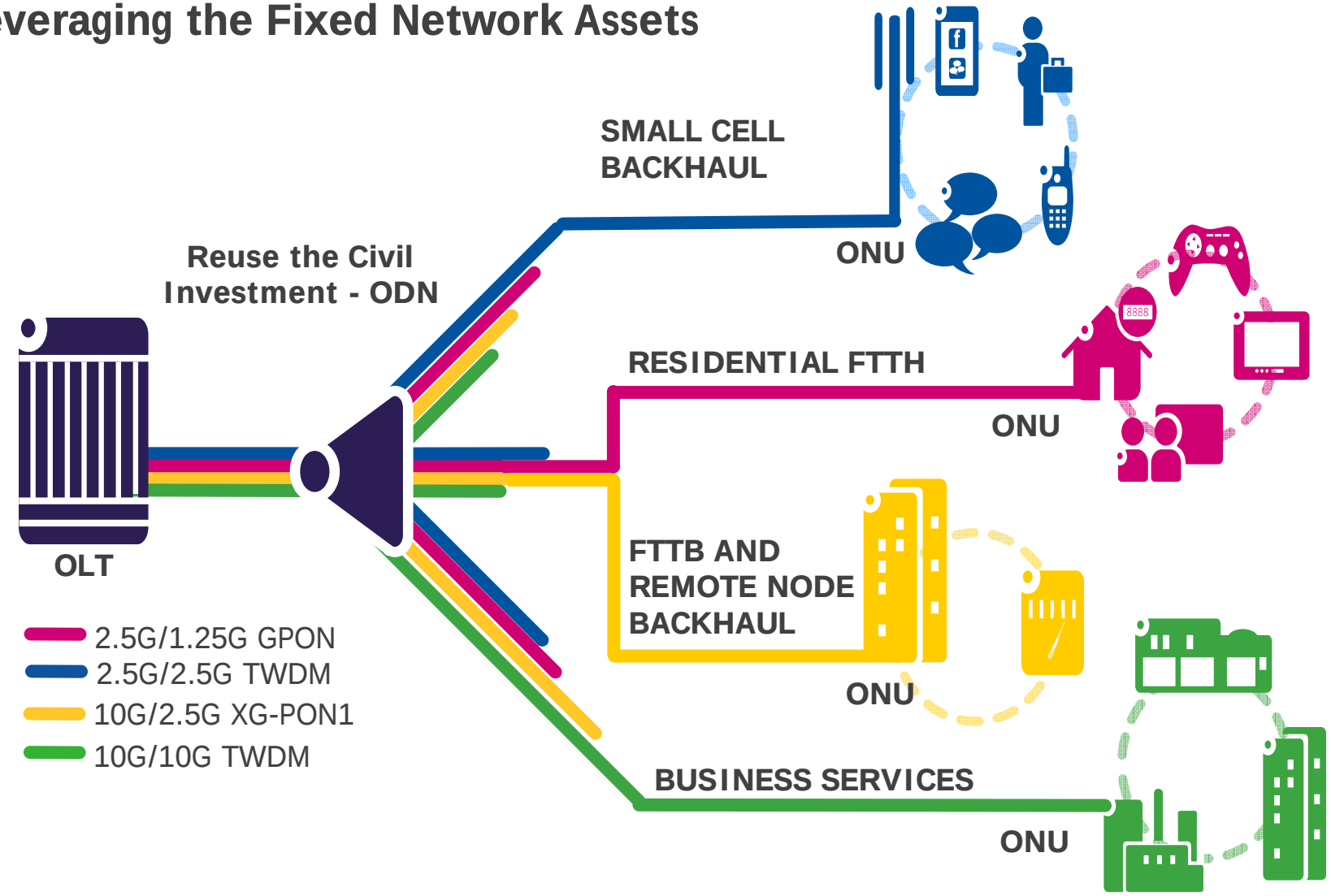
- Don't Count Copper **Out**
  - Incremental upgrade to FTTN with vectoring **can** achieve the throughput targets
  - Use bonding and small remote nodes to reach remaining subscribers
  - Beyond vectoring and bonding, loops will be getting shorter and shorter to support even higher bandwidths (>>100Mbps)
  - Operators will need to deploy remotes deeper into the network
    - CAPEX Investments
    - Remote Powering
    - Manage Operational Overhead
  - ***Then for >>100 Mbps does fiber not make more sense?***



- Passive Optical Networks offers the greatest flexibility
  - Reduction in OPEX and Maintenance
  - Differentiated bandwidth - Support for high peak bandwidth on demand
  - Longevity – deploy a network for our children and their children's generations
  - Reuse of fiber plant - support for different networks on the same fiber

Fiber Enables New Markets and Services

Leveraging the Fixed Network Assets



Not all challenges are technical ... some are organizational and operational

Further Reading

http://www2.alcatel-lucent.com/techzine/is-symmetrical-bandwidth-a-myth-or-a-must

http://www2.alcatel-lucent.com/techzine/vdsl2-vectoring-delivers-on-its-promise

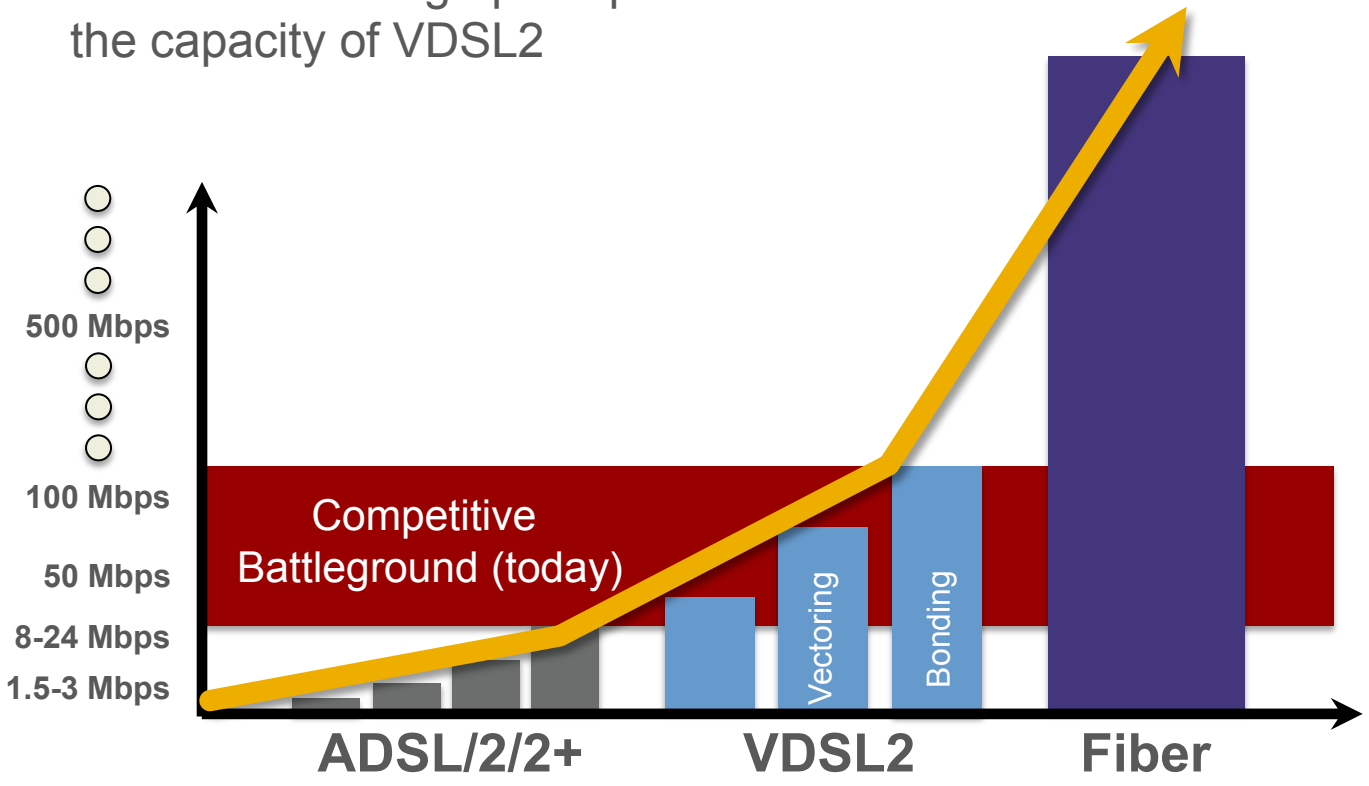
http://www2.alcatel-lucent.com/techzine/boosting-vdsl2-bit-rates-with-vectoring

AT
THE
SPEED
OF
IDEAS™

FCC Technology Transitions Policy Task Force Workshop, March 18, 2013

VDSL2: A Transition Technology

- VDSL2 provides a short term solution for bandwidth needs
- After 2020 average peak period consumer bandwidths will exceed the capacity of VDSL2



Defining Five Key Technologies

- ADSL2+-DSL technology commonly used in the U.S. today
- VDSL2-Next generation DSL technology in the process of being deployed in much of the U.S. VDSL2 products automatically fall back to ADSL2+ when that technology has superior performance
- Bonding-Utilizing 2 or more pairs of copper to increase bandwidth or the loop length of a given bandwidth. Bonding can be done on both ADSL2+ and VDSL2 technologies
- Vectoring-A signal processing technology that reduces the impact of noise in VDSL2 system
- FTTH-Fiber-to-the-Home utilizes either passive (PON) or active (Pt-to-pt Gigabit Ethernet) to bring bandwidth directly to the customer premises

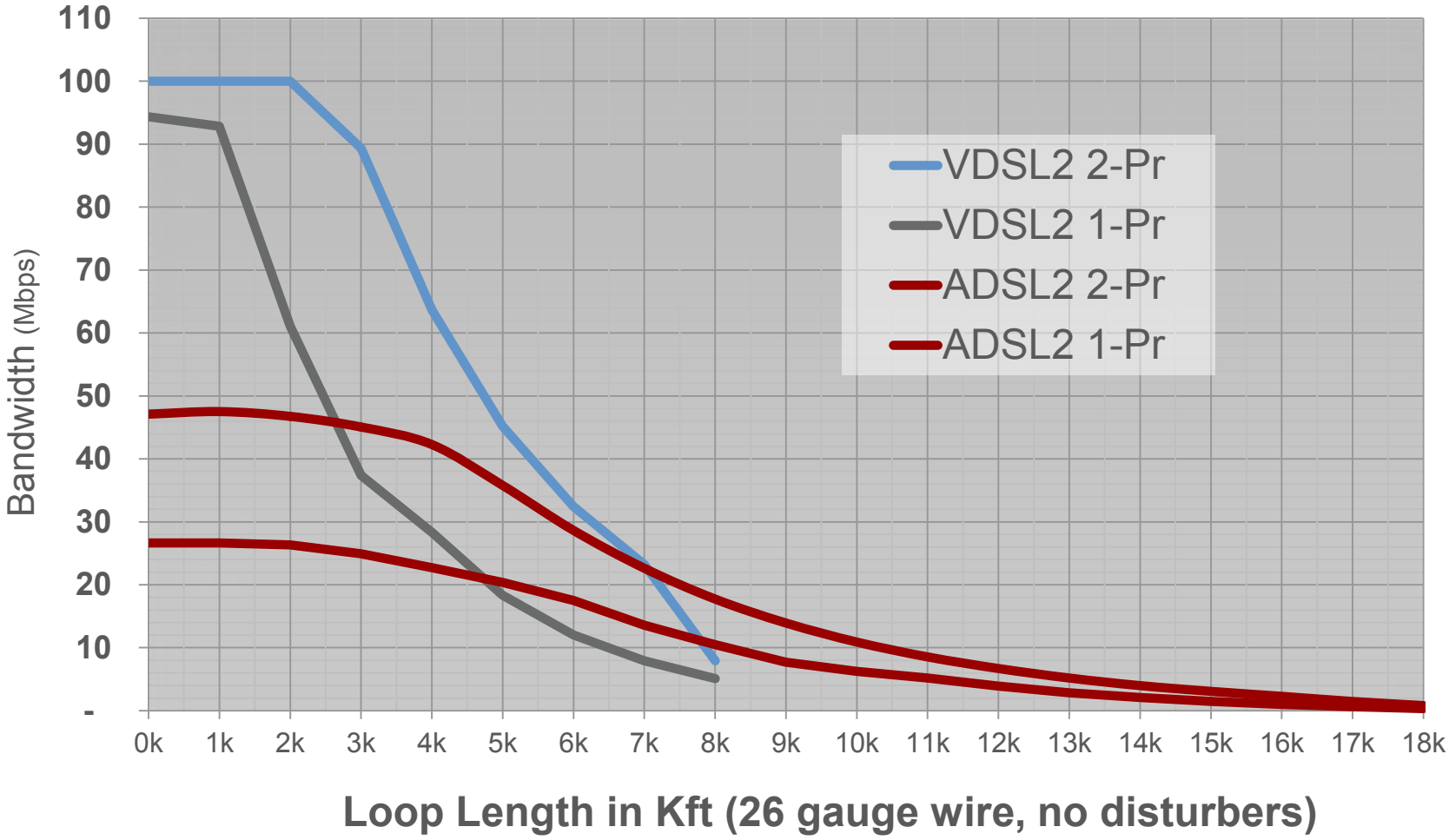
VDSL2 Profiles for Different Applications

VDSL2 differs dramatically from ADSL2+ with the use of profiles

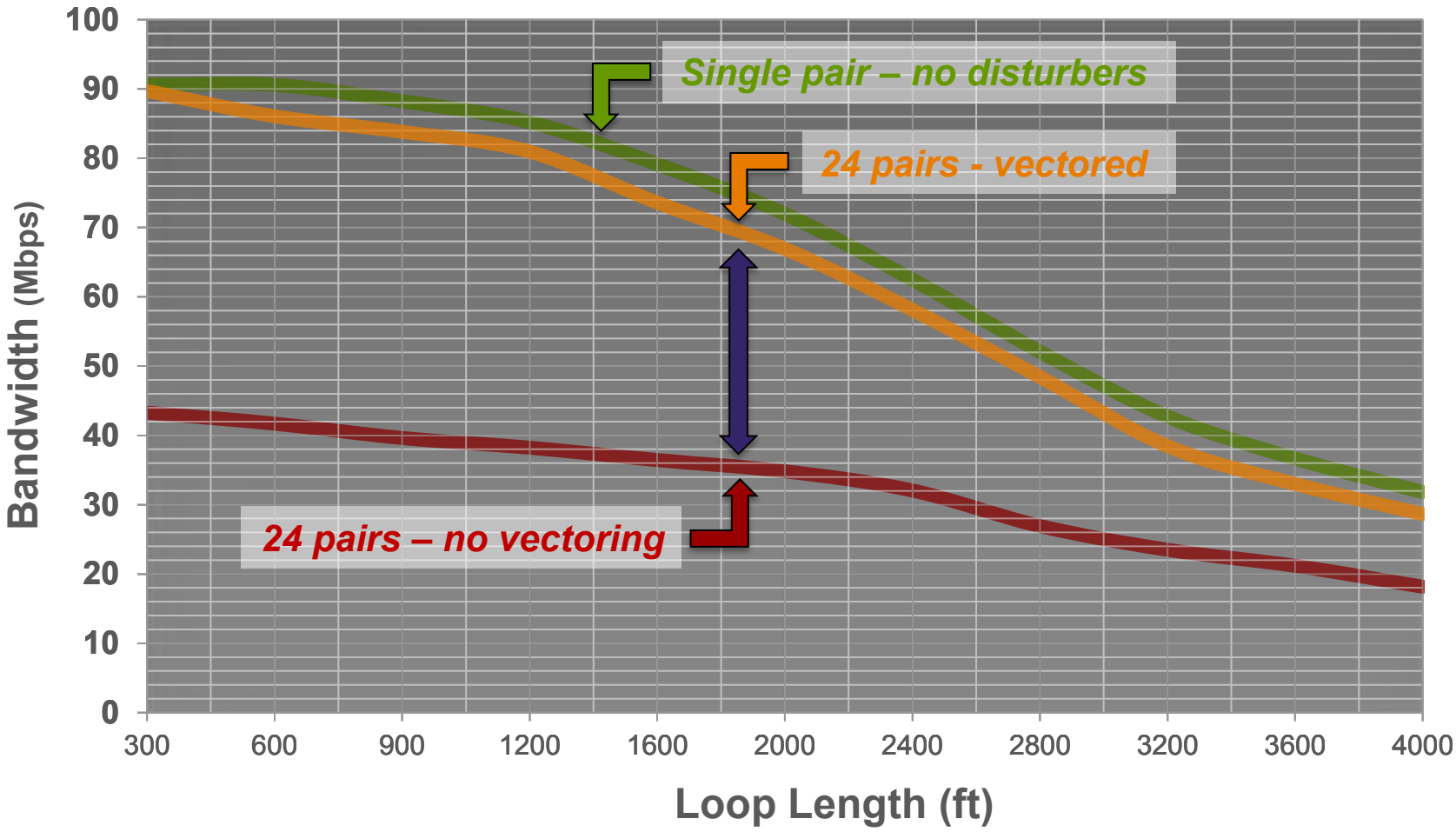
- Profiles differ dramatically in their performance over distance

	Max. DS Power	Max. Freq.	**Bandwidth** (Max Downstream)	**Bandwidth** (Max Upstream)	Typical Application
Profile 8b	20.5 dBm	8.5 MHz	**90 Mbps**	**20 Mbps**	CO
Profile 8a	17.5 dBm	8.5 MHz	**90 Mbps**	**20 Mbps**	CO
Profile 8d	14.5 dBm	8.5 MHz	**90 Mbps**	**20 Mbps**	RT
Profile 8c	11.5 dBm	8.5 MHz	**90 Mbps**	**20 Mbps**	RT
Profile 12a	14.5 dBm	12 MHz	**90 Mbps**	**60 Mbps**	Node
Profile 12b	14.5 dBm	12 MHz	**90 Mbps**	**60 Mbps**	Node
Profile 17a	14.5 dBm	17.7 MHz	**100 Mbps**	**60 Mbps**	MDU
Profile 30a	14.5 dBm	Not Generally Supported in North America			MDU

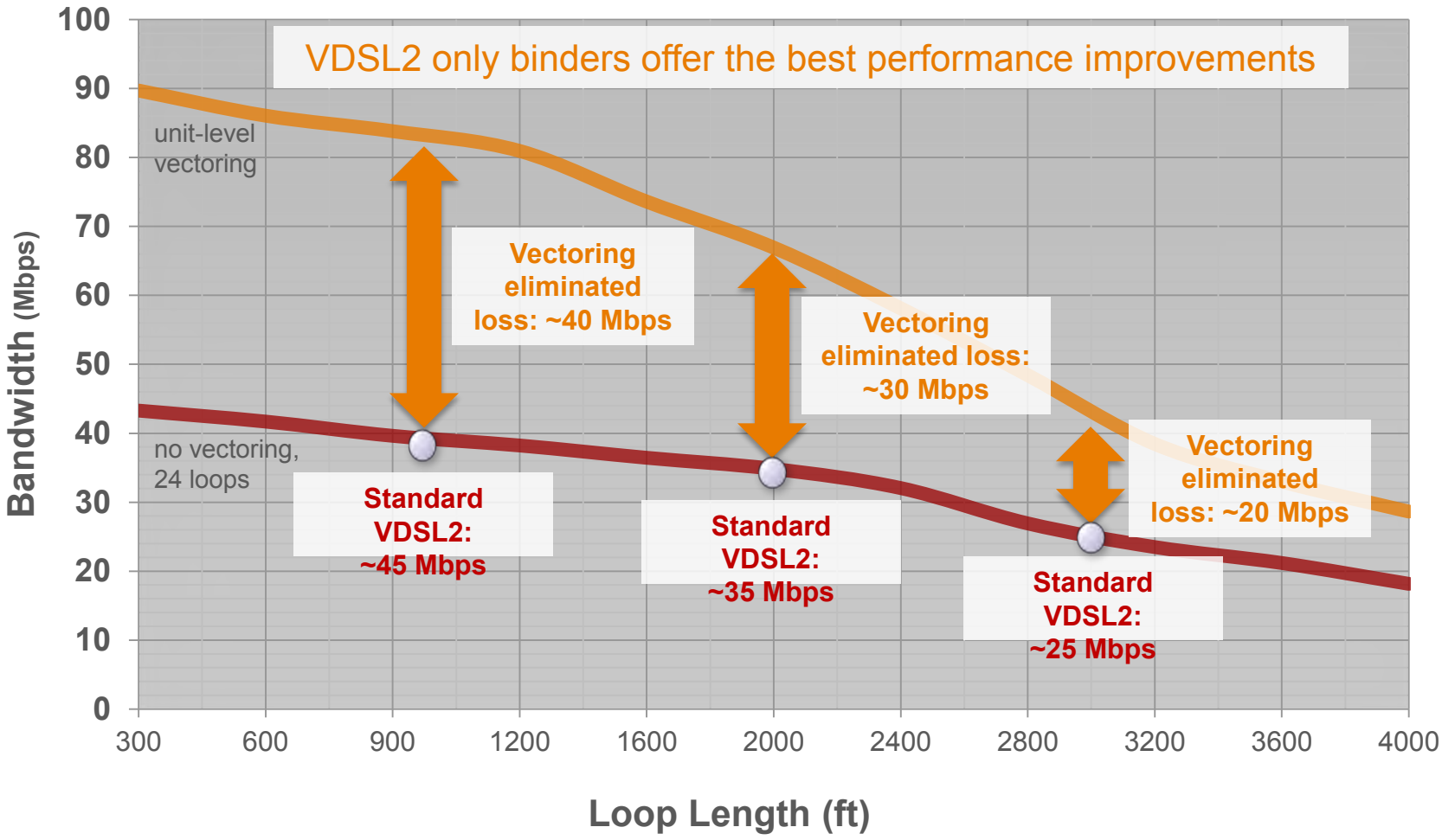
DSL Performance and Bonding



VDSL2 Performance

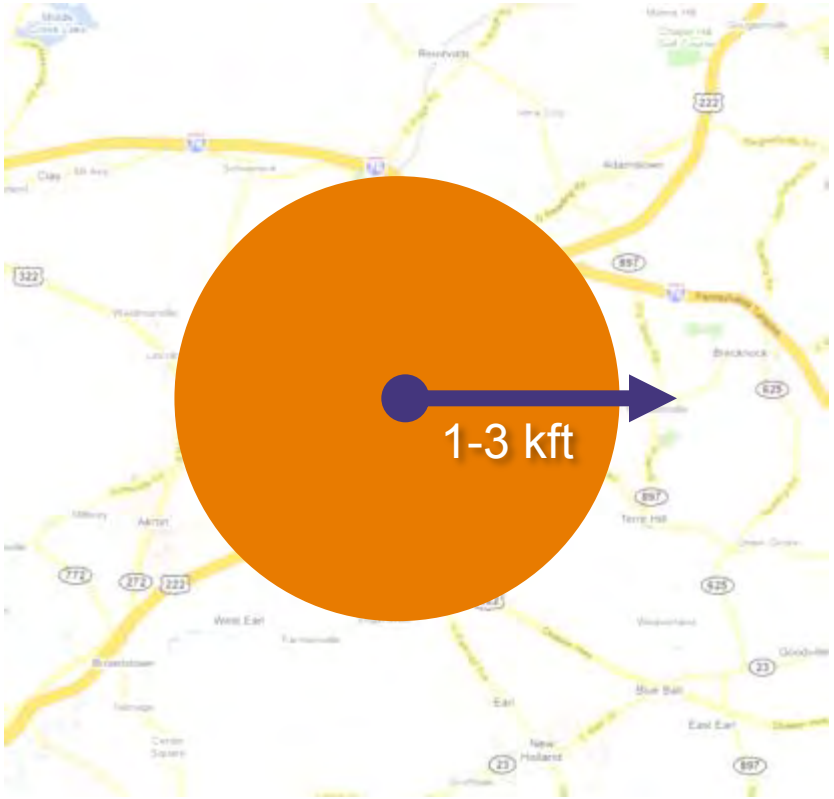


VDSL2 Take Rate Impact on Vectoring



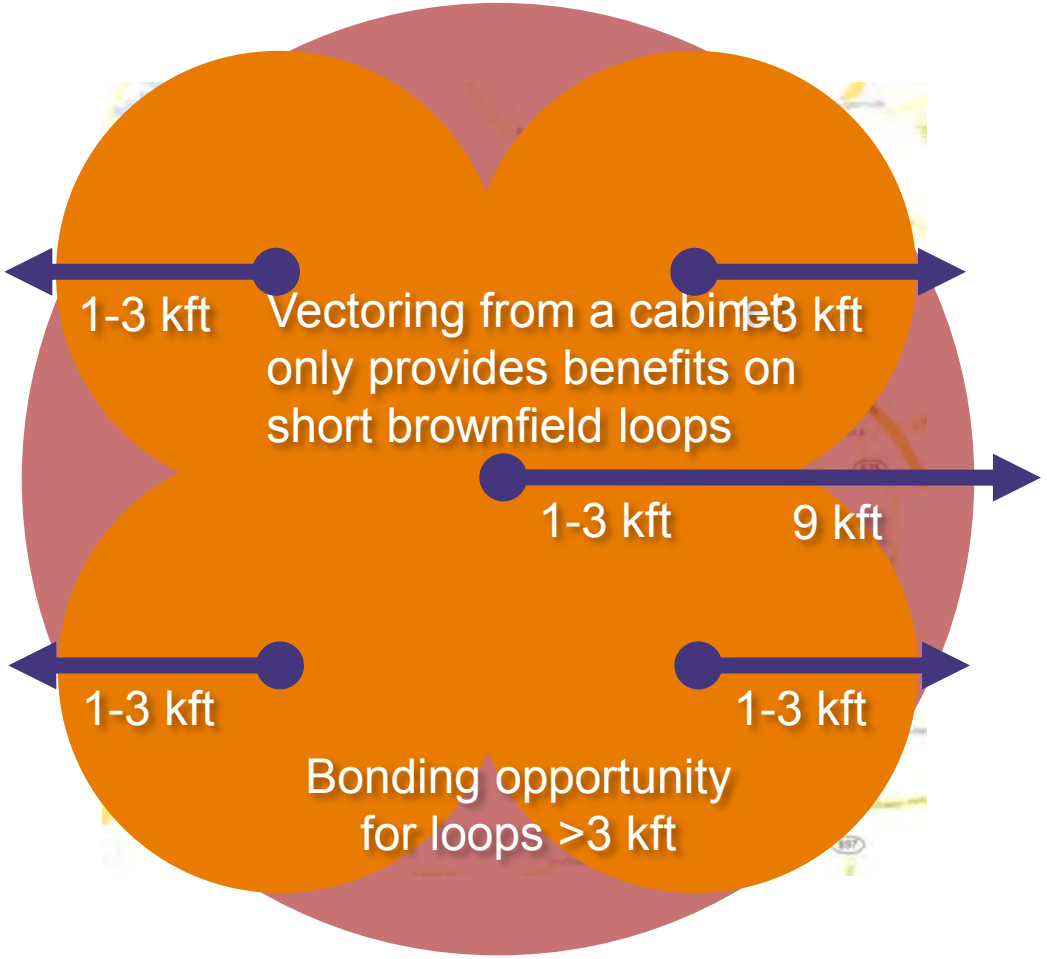
VDSL2 Applications

- **Greenfield** (1-3 kft)
  - New deployments…but these can justify FTTH
  - Short copper loops so bandwidth is optimized
  - Vectoring good to ~3kft



VDSL2 Applications

- **Brownfield** (up to 7 kft)
  - Deployments often served from existing cabinets
  - Density designed to serve high subscriber counts, or subscribers geographically dispersed (multiple binders)
  - Mix of short and long loops
  - Vectoring of no benefit between 3-9 kft
- **Opportunities to improve bandwidth**
  - Bonding on loops longer than 3Kft
  - Shorten copper loops by extending fiber



VDSL2 Deployment Challenges

VDSL2 is a beneficial technology…but faces real-world deployment challenges

- Age of copper plant – may require maintenance upgrade
  - Old splices, bad pairs, water, etc.
- Interferers and ADSL2+ loops reduce benefit of vectoring
  - May require labor intensive binder grooming, plant and record management
- Little benefit on longer loops
  - Bandwidths fall to ADSL2+ and below levels
- Bonding yields rate and reach benefits if pairs are available
  - Pairs are not plentiful enough in many areas to allow for wide use of bonding

Optimal Technology 2013-2018

- VDSL2 short loop lengths (up to 9 kft) satisfy denser areas
- FTTH loop lengths of over 20 miles are optimal for less dense areas
- Wireless and satellite become optimal as housing densities make FTTH less viable economically

	Urban	Suburban/ Rural Towns	Rural 10-100 subs per sq/mile	Rural 2-10 subs per sq/mile	Rural Less than 2 subs per sq/mile
Greenfield or Rebuild	FTTH or VDSL2 w/vectoring	FTTH or VDSL2 w/vectoring	FTTH	Wireless	Satellite
Brownfield	VDSL2	VDSL2	ADSL2+	Wireless	Satellite

Calix

Birds Eye View of Example Service Area

From Wireline to Wireless Broadband

Prof. Dina Katabi

Director of the MIT Center for Wireless Networks and Mobile Computing (Wireless@MIT)

wireless @mit

http://wireless.csail.mit.edu

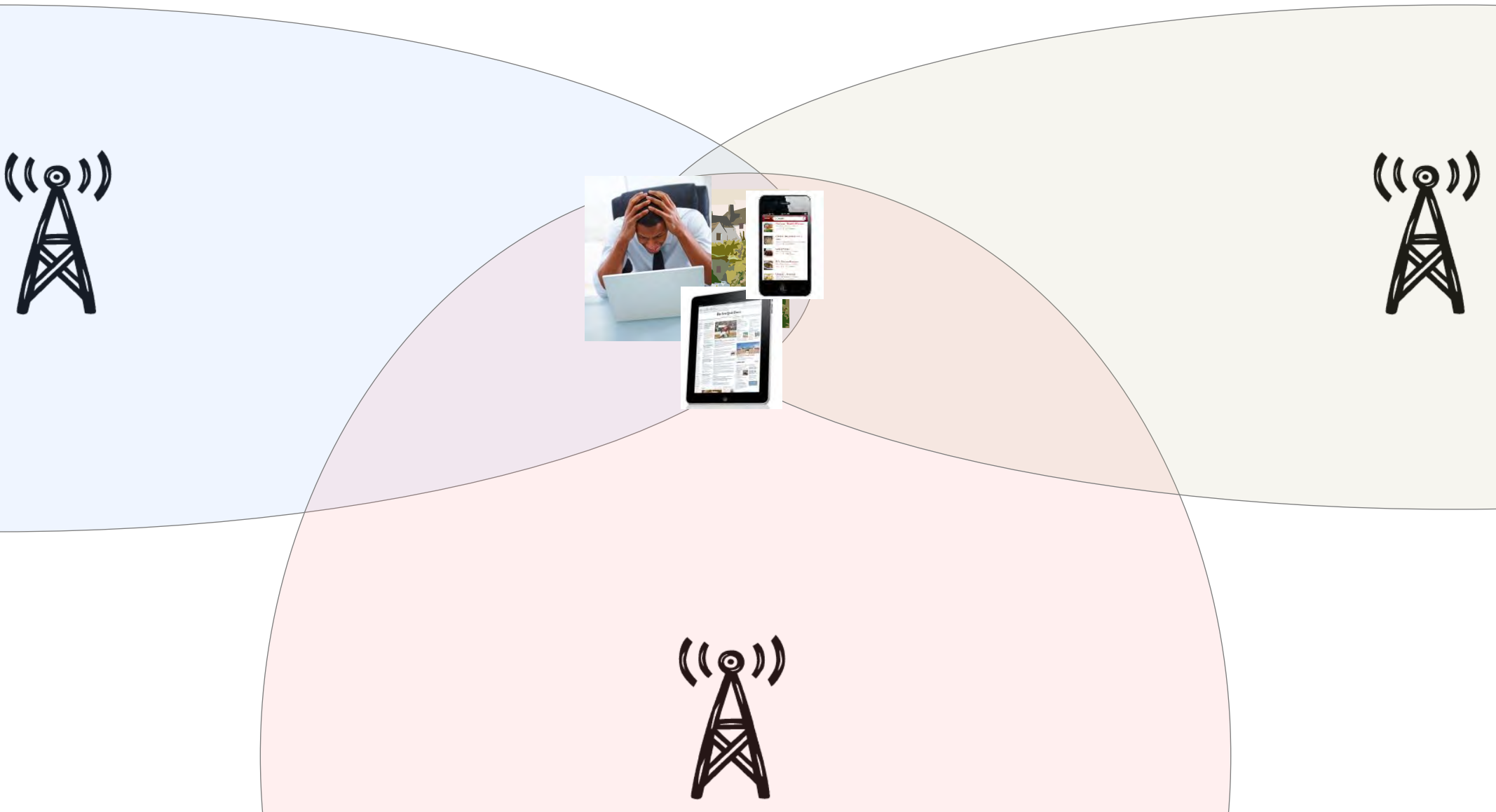
Can Wireless Replace Wireline Broadband, Particularly in Rural Areas?

- Technologically can deliver high-capacity to communities with no wireline connectivity
  - 3G or 4G alone will not do
  - Need to deploy innovative technologies

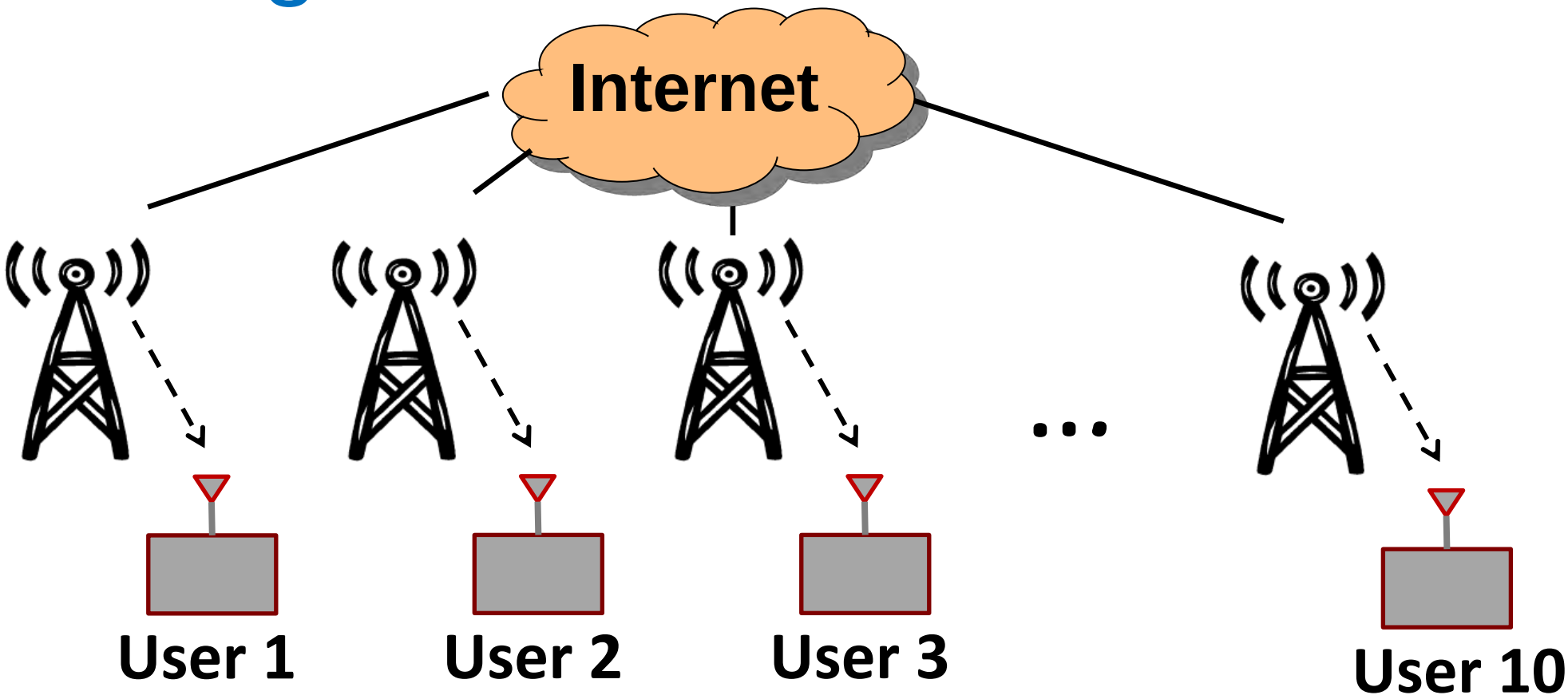
High-Capacity Technologies

- Get the best out of the spectrum you have
  - Interference Alignment
  - Distributed MIMO -- MegaMIMO
- Dynamic spectrum sharing
  - GHz realtime low-cost spectrum sensing

What if many base stations coordinate and act as a powerful distributed MegaMIMO base station?



MegaMIMO: Distributed MIMO

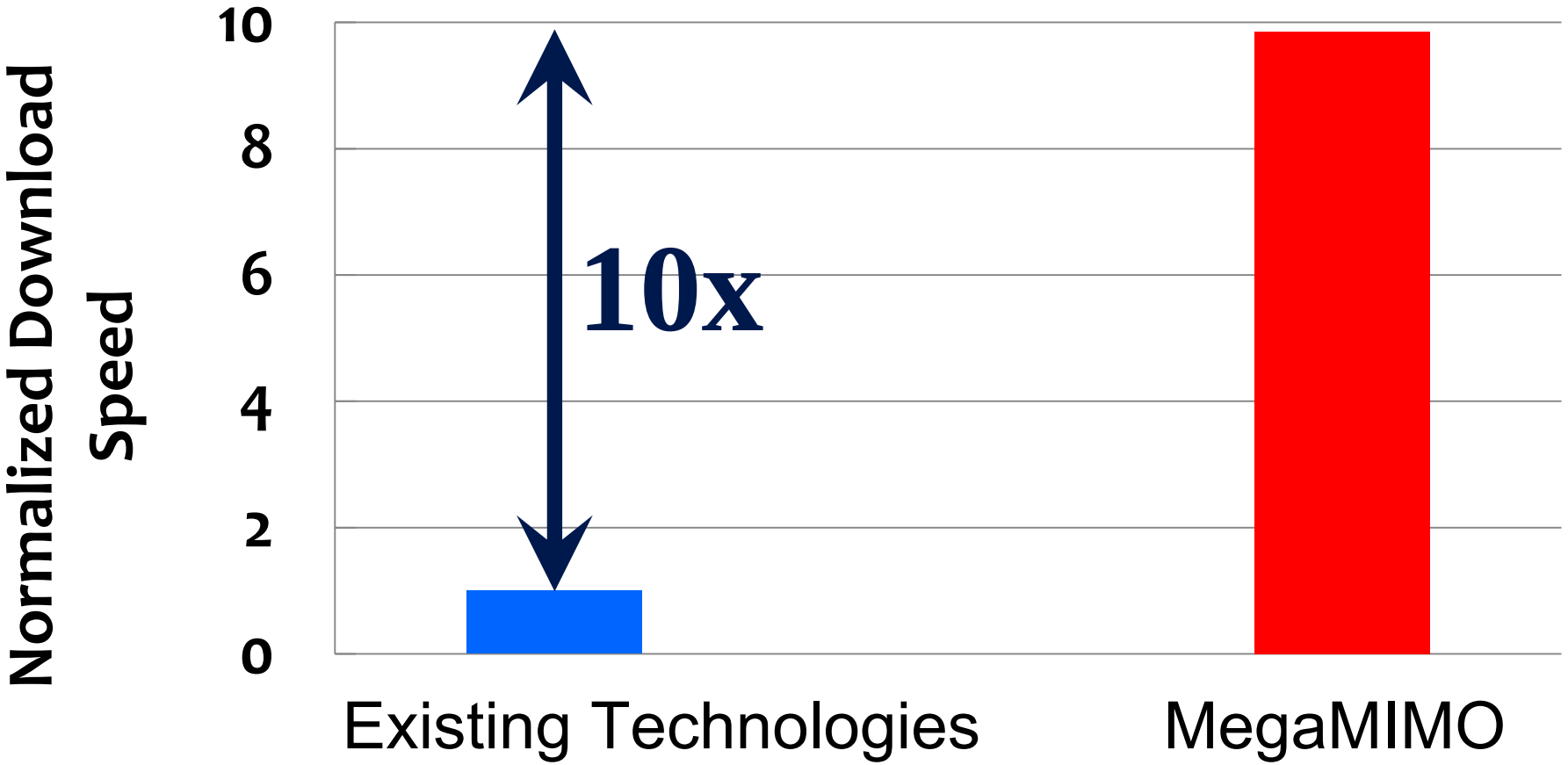


MegaMIMO enables BSs to act as a huge MIMO transmitter with sum of antennas

10 BSs on same band → 10x higher throughput

Testbed of Software Radios

Results from In-Lab Prototype



10x gain in actual data rates (not maximum theoretical)

groups.csail.mit.edu/netmit/wordpress/projects/

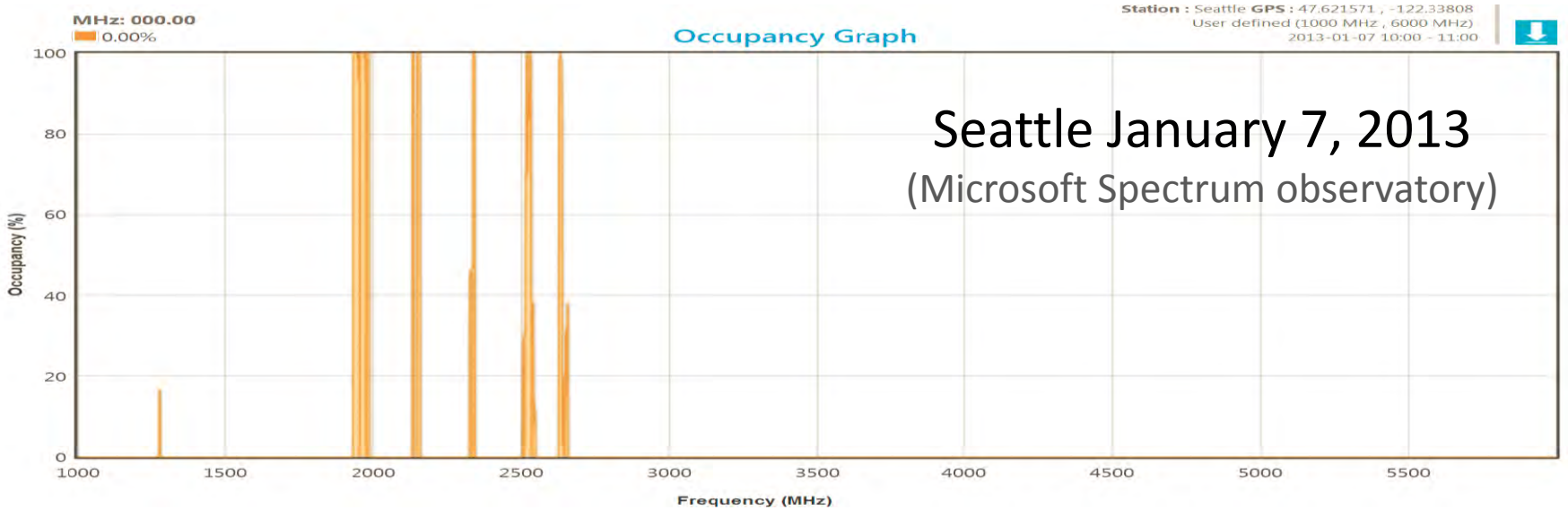
GHz Realtime Low-Cost Spectrum Sensing

- Today, can't capture very wide spectrum in realtime

- Sequential scanning of tens of MHz

  ➔ Can easily miss radar signals

Idea: Leverage Sparsity



Sparse recovery show that one can acquire sparse signals using sub-Nyquist sampling

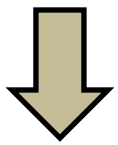
Sparse FFT

Winner of TR10, 2012 (Technology Review); Featured in IEEE Spectrum, Discover magazine, BBC radio, Slashdot, …

http://groups.csail.mit.edu/netmit/sFFT/

Benefits of Sparse FFT

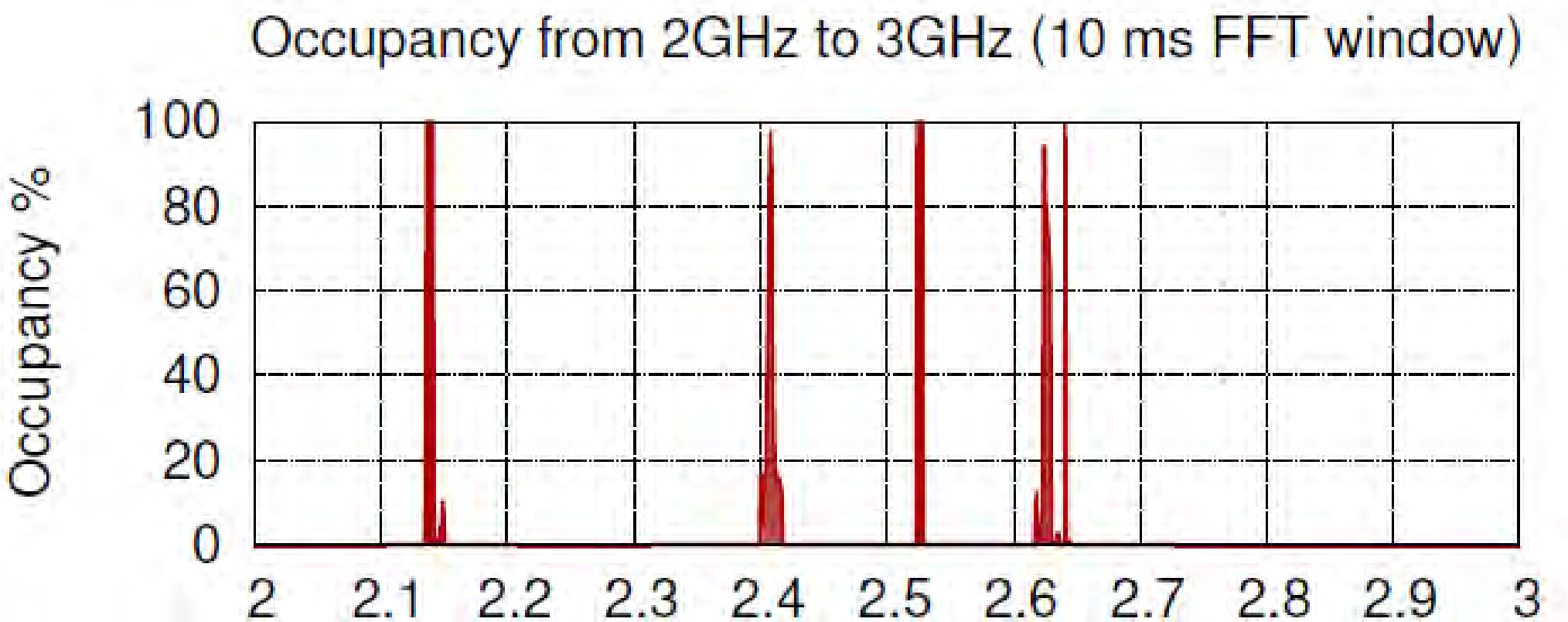
- Sub-sample the data → Can use low-speed ADCs
- Very fast algorithm → Lower-power consumption



- Used sparse FFT to build a GHz receiver from three 50 MHz software radio
- Both senses and decodes sparse spectrum

Realtime GHz Spectrum Sensing

Cambridge, MA January 18 2013



sFFT enables realtime low-cost GHz sensing and decoding

Wireless Technology Transition

Mung Chiang
Princeton University EDGE Lab

Technology Transition > Technology

- Phasing out is even more challenging than rolling out

- Is the technology backward compatible?
- Is the benefit incrementally deployable?
- Is the cost incentive compatible?
  - Human cost
  - Equipment cost
  - Spectrum cost

From Harmonization to Scale

LTE Today

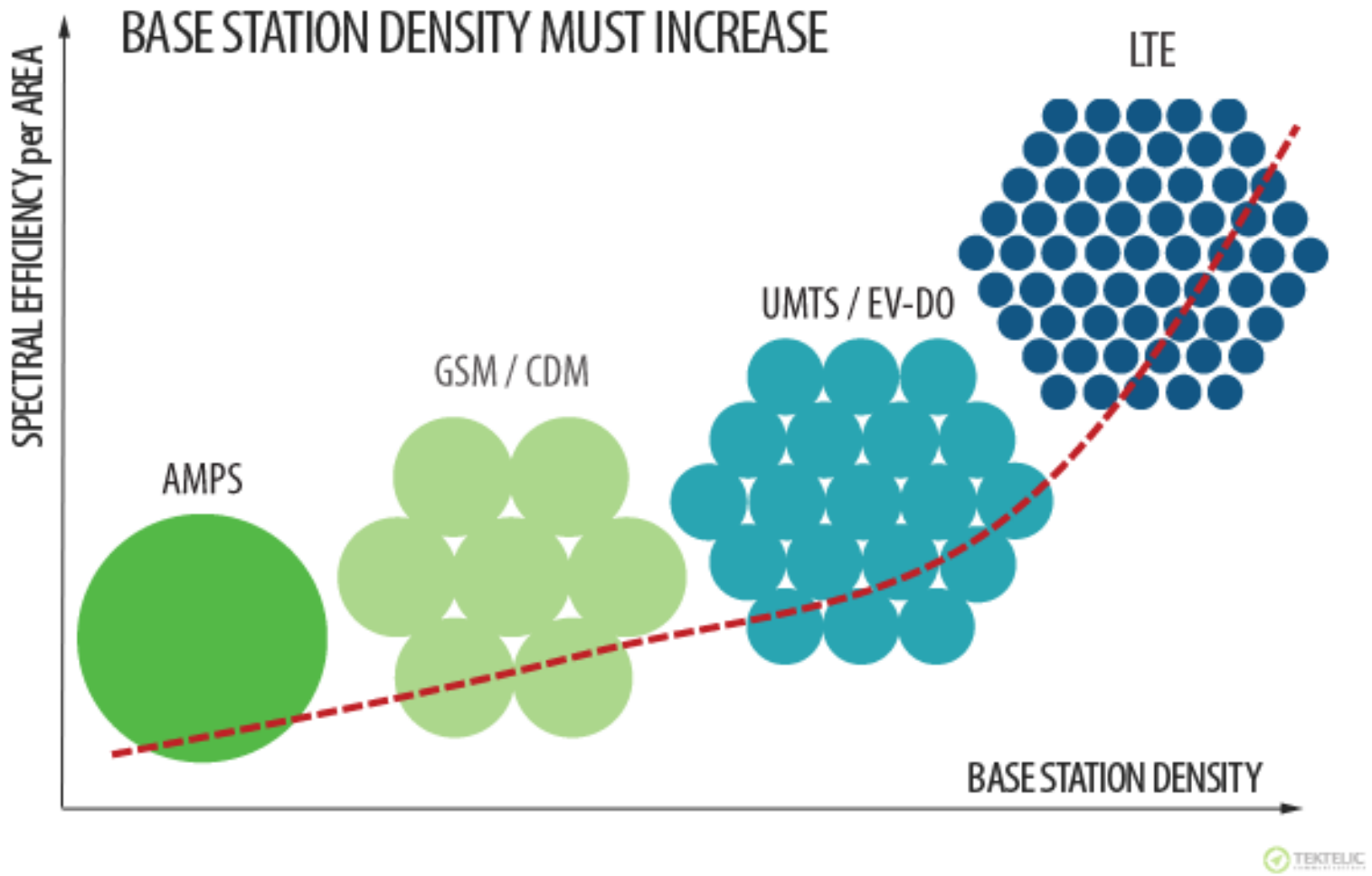
- LTE is great because:
  - Efficiency (b/s/Hz): Higher speed
  - Architecture (IP): Simpler and faster
  - Harmonization
- What about:
  - Fixed wireless: rural and urban dense
  - Copper: help with small cell backhaul

LTE Tomorrow

- Carrier aggregation in LTE Advanced, Voice over LTE…
- From capacity-focus to coverage-enhancement, SON…
- Supply-Demand match: Grand challenge of 1000X

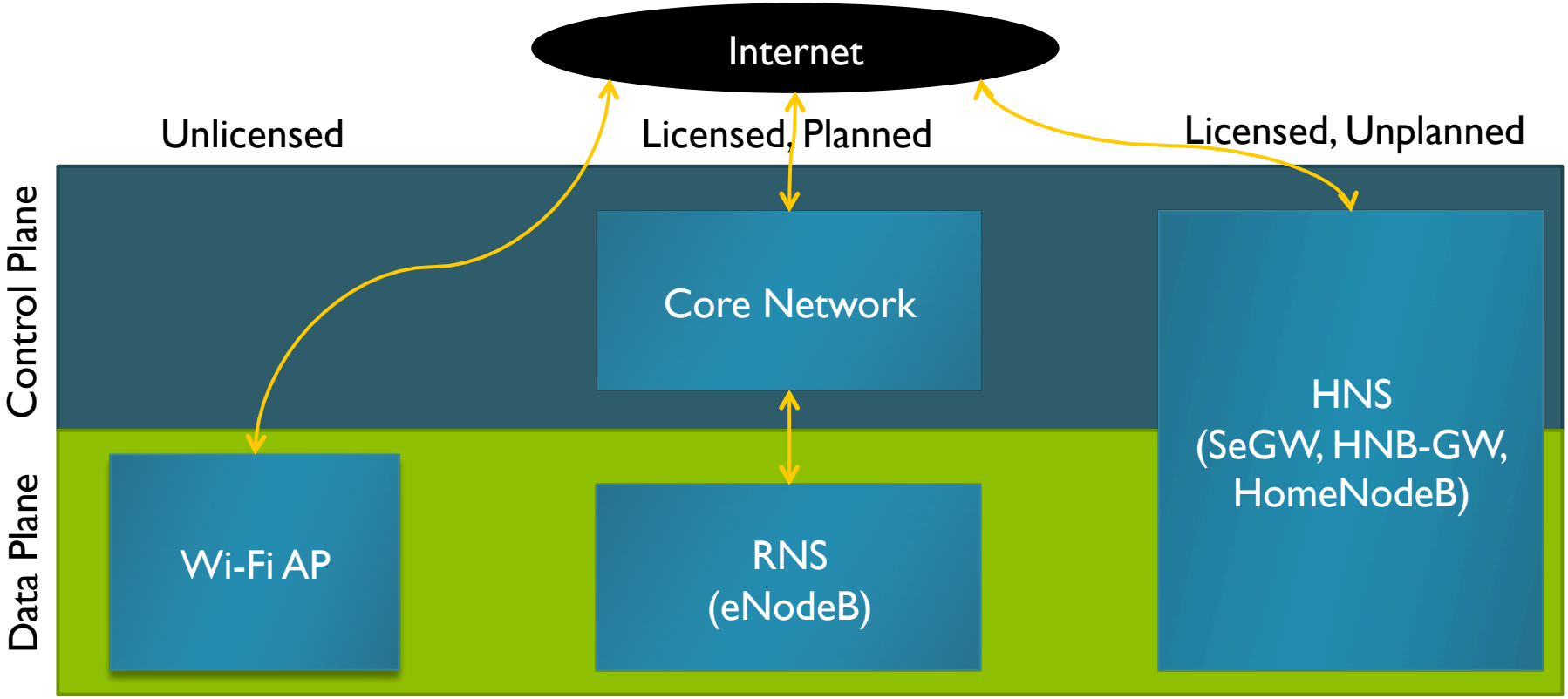
- M2M opportunities and signaling optimization…
- Consumer QoE: From smart phones to smart data

Supply: Smaller



Supply: Denser

Supply: “Wilder”



Demand: Smart Data-Pricing (SDP)

- Smarter sharing on "demand side"
- Application-layer, end-user-driven, tiered sharing & reuse
- "5G":
  - user experience
  - personalization
  - app economics
  - pipe-content divide

- MTA – Princeton trial in rural Alaska

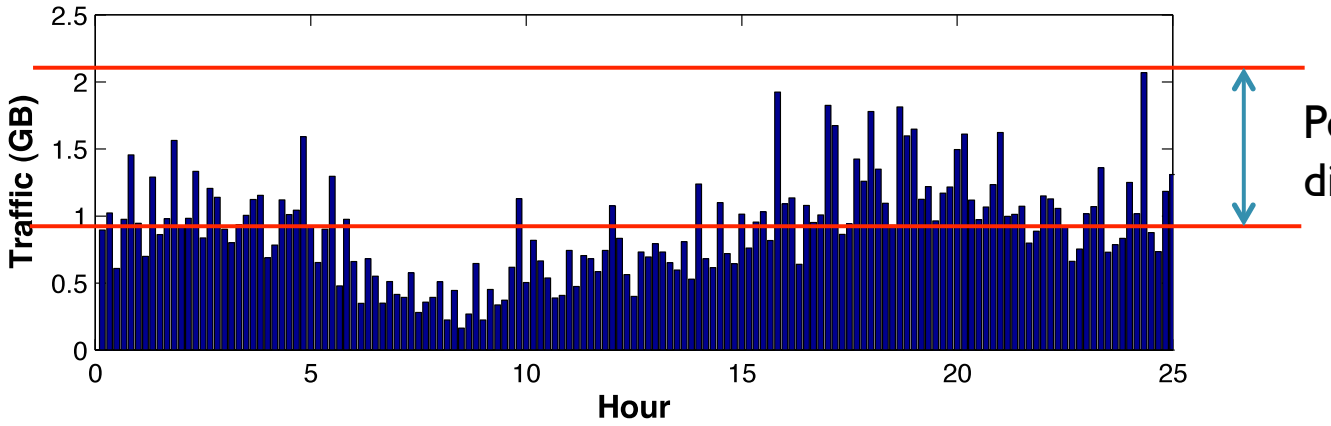
Why: Jobs' Inequality of Capacity

Growth in Mobile Data Demand

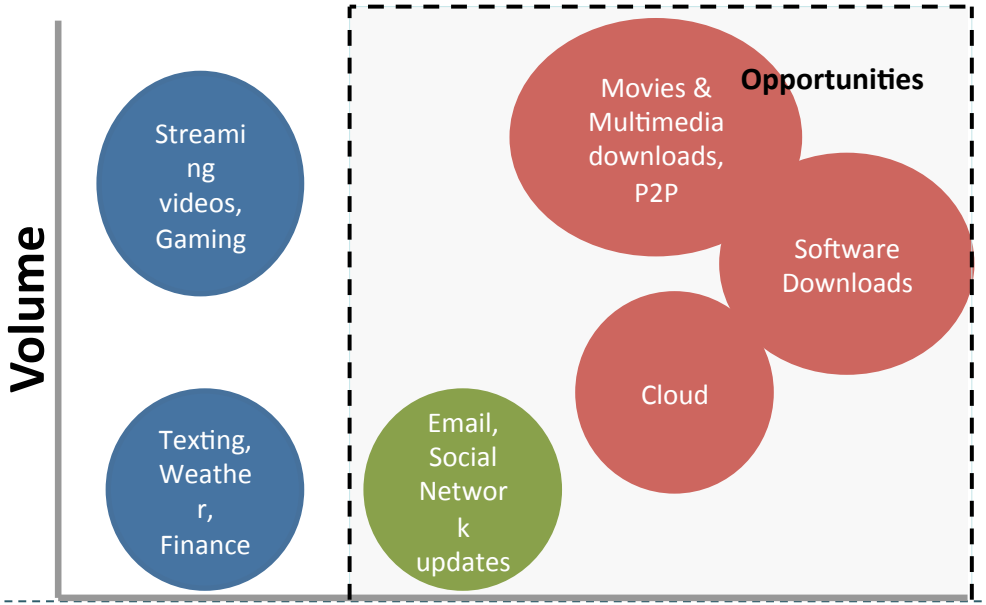
Mobile Video + Cloud Services + Data-Hungry Apps + High-Resolution Devices = Rapid growth in demand for mobile data

Annual Growth Statistics				
Mobile Video	Total traffic (2011)	62%	Streaming CAGR (2011 – 16)	34%
Source: Cisco VNI 2011 – 2016 (http://www.tinyurl.com/VNI2012)				
Cloud Services	Consumer traffic (2011)	83%	Consumer Traffic CAGR (2010 – 15)	67%
Source: Cisco Global Cloud Index 2010 – 15 (http://tinyurl.com/CiscoCloud2010)				
Data-Hungry Apps	Facebook (2010)	267%	Skype (2010)	87%
Source: Allot Global Mobile Trends Report 2011 (http://money.cnn.com/2011/02/08/technology/smartphone_data_usage/index.htm)				
High-Resolution Devices	iPad2	1024 x 768 pixels	iPad LTE	2048 x 1536 pixels
Source: Apple (http://www.apple.com/ipad/compare/)				

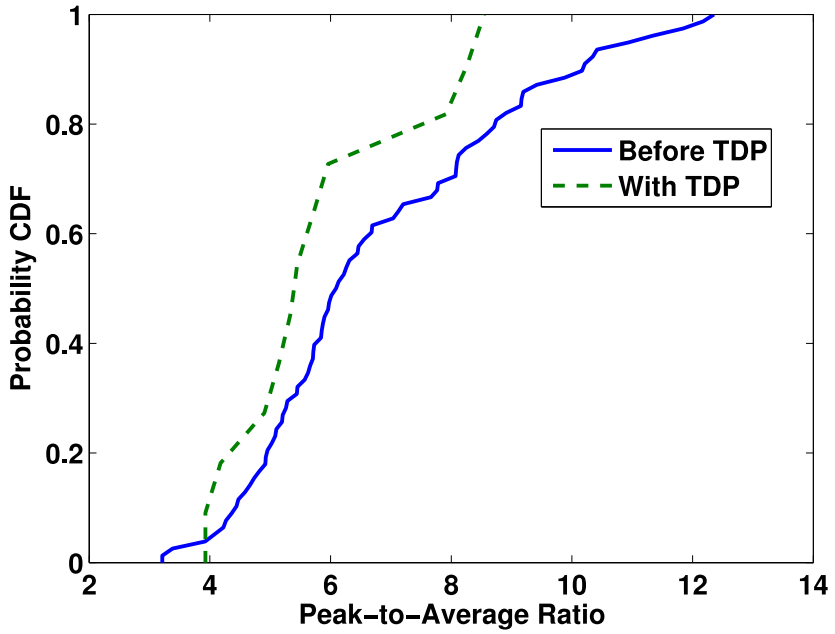
Waste and Opportunity in "Time"



Peak-average discrepancy

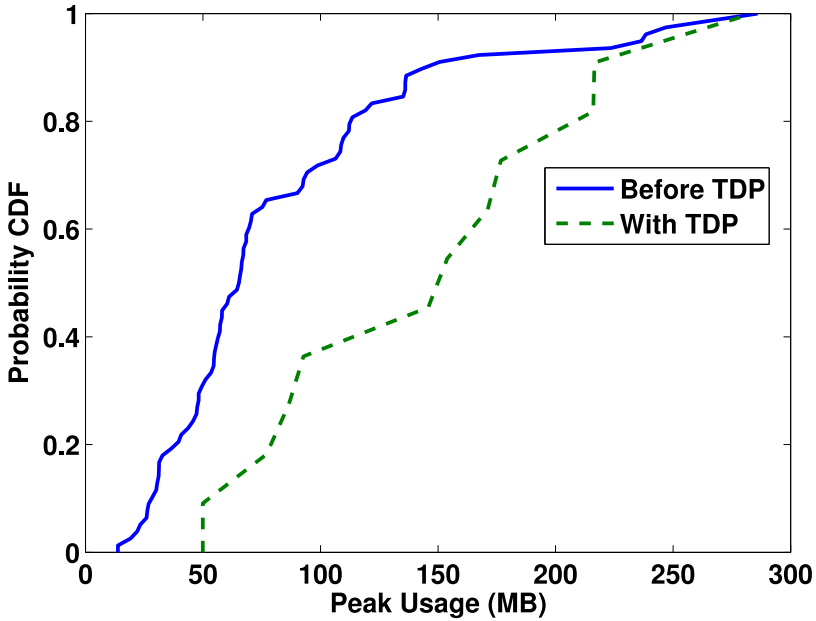


Time Shifting: Princeton Trial

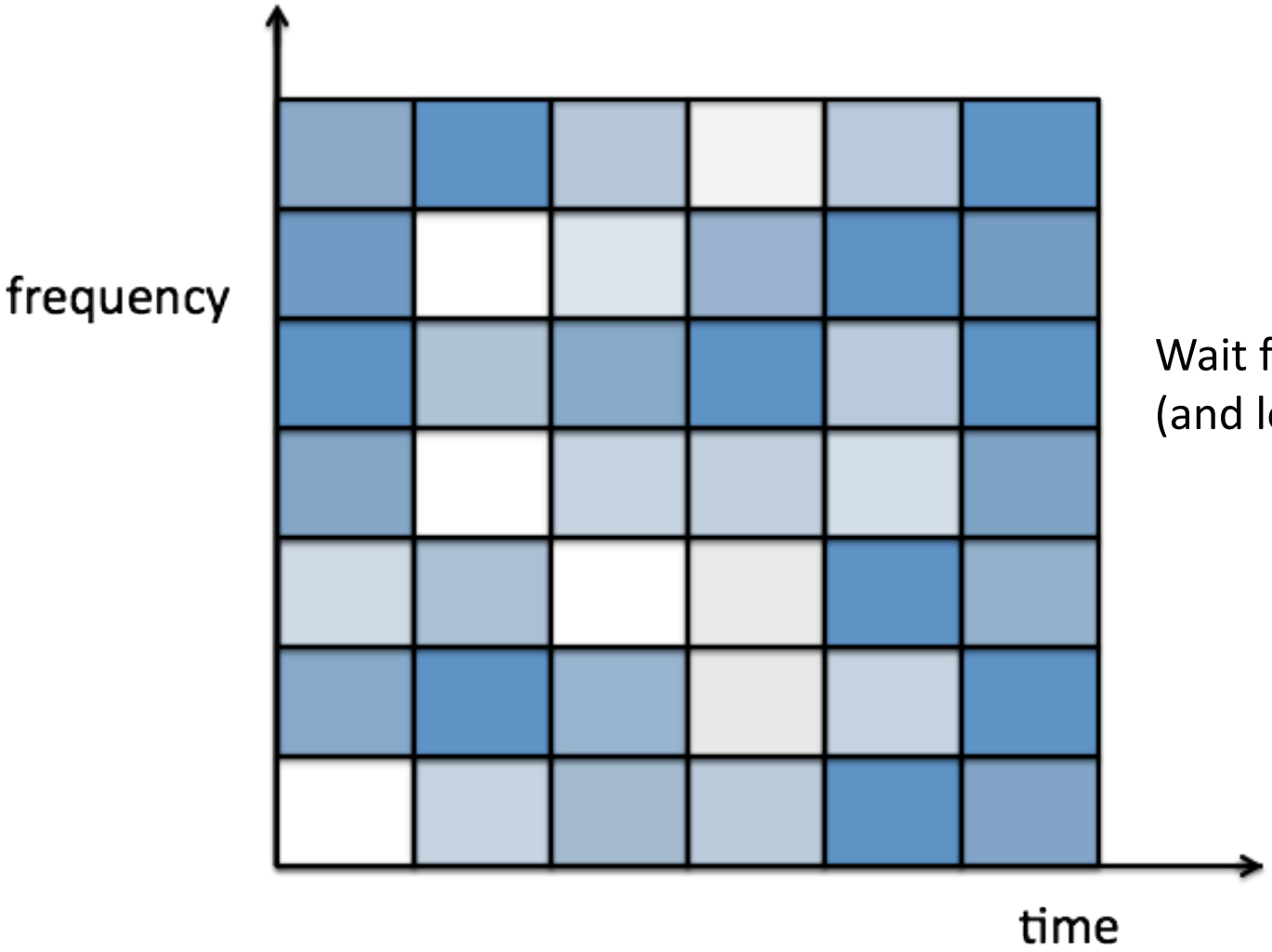


Maximum PAR decreases by 30%

Overall usage increases 130%



What's More: "Flashy" Whitespace

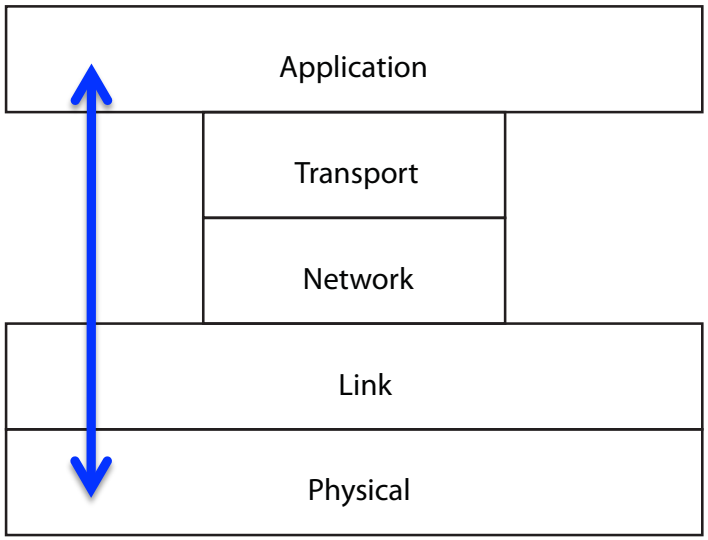


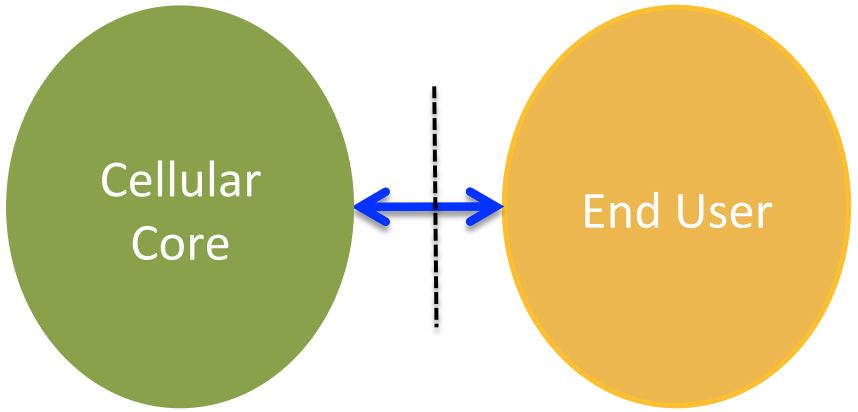
Wait for less congested (and lower priced) time

Paradigm Shift

- Stop (just) counting bytes and start living with QoE
  - Recognize and leverage heterogeneity of apps and networks
- Win – Win – Win
  - Consumers: more choices and lower $/GB
  - Carriers: lower cost and higher revenue
  - Content/App providers: more engaged eyeballs

Where to Innovate?



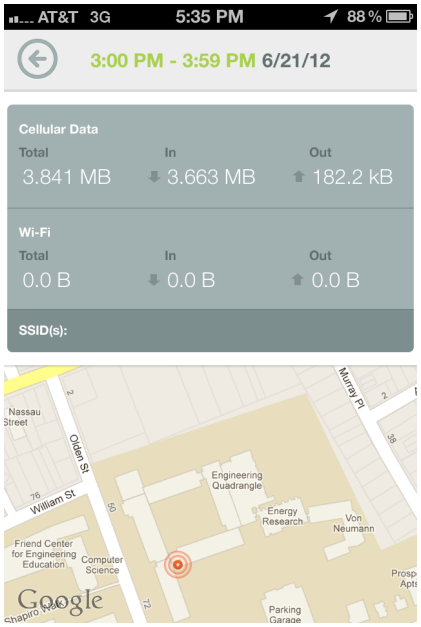


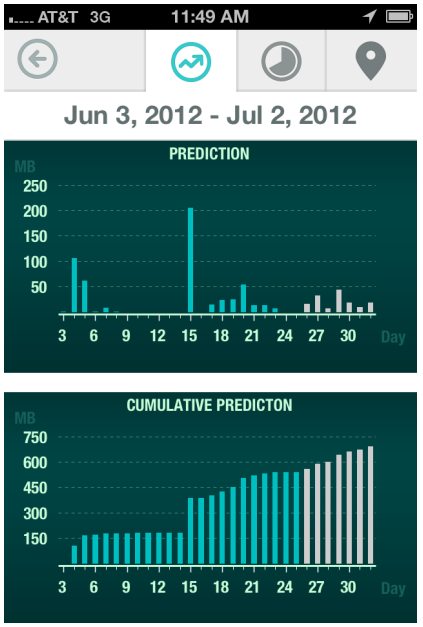
Smart sharing in APP + PHY

Mobile management from the edge

By the Users, Of the Users, For the Users

DataWiz App





Thank you

- chiangm @ princeton.edu
- http://scenic.princeton.edu

Cable Technology Overview - FCC Technology Transitions Policy Task Force Workshop

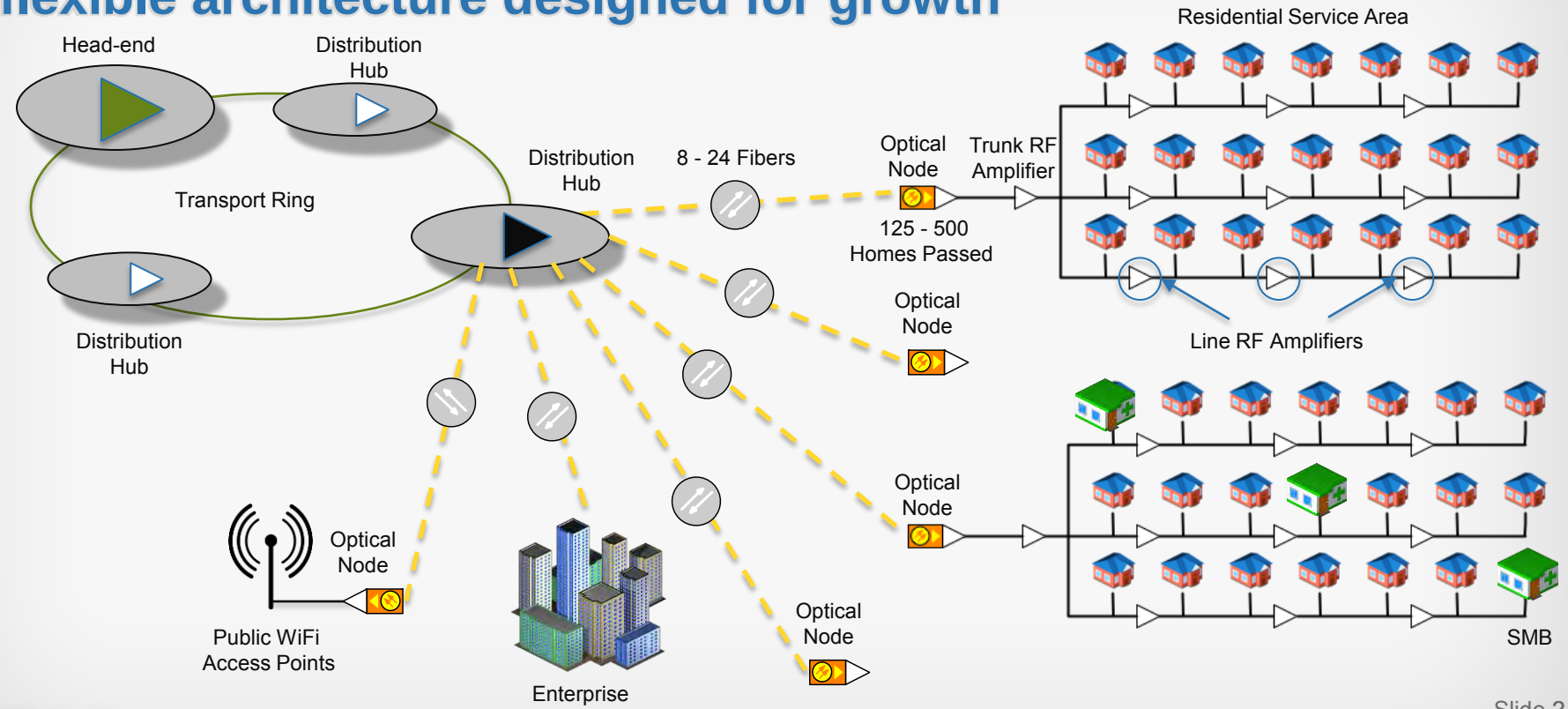
CableLabs®

Ralph W. Brown, CTO

March 18, 2013

Cable Hybrid-Fiber Coax (HFC) Architecture

A flexible architecture designed for growth



Cable Hybrid-Fiber Coax (HFC) Architecture

A flexible architecture designed for growth

- HFC enables evolution from analog linear TV services only to:
  - Analog and digital linear TV services (both SD and HD)
  - Switched digital TV services (e.g. VoD and SDV)
  - Broadband Internet access services
  - VoIP telephony services
  - Home security services
  - Managed IP cable services
- Cable operators have also deployed over 120,000 public WiFi access points
- Cable operators also provide services to small, medium and large businesses

Diversity of Cable Systems

Not all cable systems are the same

- Key HFC characteristics impacting network capacity that vary:
  - Cable system spectrum typically is 750 or 860 MHz, but may vary from as low as 450 MHz to as much as 1 GHz
  - Typical node segment size is less than 500 HHP, but may be as high as 1,000 HHP
  - Number of amplifiers in cascade from zero to 5 or 6
- Each cable operator must assess how to optimize the deployed HFC network (segment nodes, upgrade network to expand frequency limits, reduce or eliminate analog channels, etc.)

DOCSIS® Technology Evolution

DOCSIS Version	DOCSIS 1.0	DOCSIS 1.1	DOCSIS 2.0	DOCSIS 3.0	DOCSIS 3.1
Example Services					
Broadband Internet	X	X	X	X	X
Tiered Services		X	X	X	X
VoIP		X	X	X	X
Video Conferencing			X	X	X
SMB Business Services			X	X	X
Entertainment Video				X	X
Enterprise Business Services					X
Example Customer Premise Devices					
Cable Modem	X	X	X	X	X
VoIP Phone (MTA)		X	X	X	X
Residential Gateway		X	X	X	X
Video Conferencing			X	X	X
Mobile Devices				X	X
IP Set-top Box				X	X
Business Services Gateway					X
Downstream Bandwidth					
Capacity in bits-per-sec	40 Mbps	40 Mbps	40 Mbps	**160 Mbps min**	**Target 1 Gbps min**
Upstream Bandwidth					
Capacity in bits-per-sec	10 Mbps	10 Mbps	30 Mbps	**120 Mbps min**	**Target 200 Mbps min**

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DOCSIS 3.1 Technology

Cable continues to invest

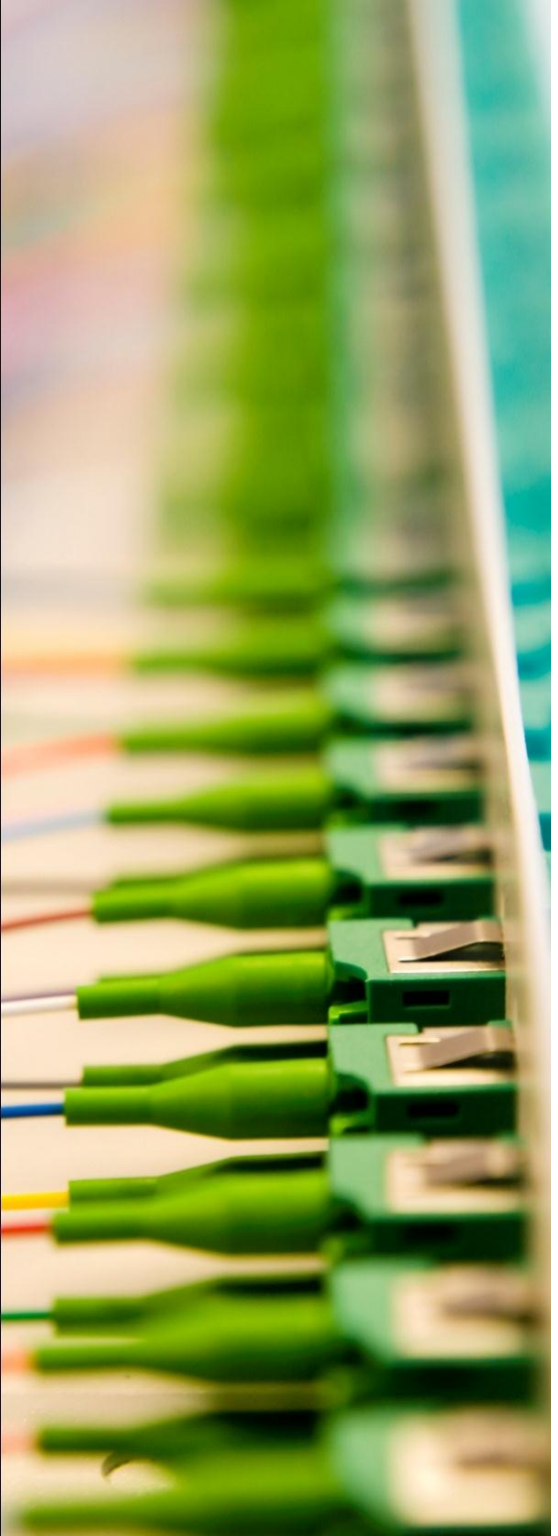
- What's new in DOCSIS 3.1?
  - More efficient modulation and FEC (OFDM, OFDMA, LDPC)
  - Enables new downstream and upstream spectrum allocations
  - Extensive re-use of DOCSIS 3.0 concepts
  - Energy efficient operation through traffic-load based duty cycle
- Backward compatibility with earlier versions
  - DOCSIS 3.1 cable modems can be upgraded before head-end and can coexist with older versions (1.1, 2.0, and 3.0)
- DOCSIS 3.1 specifications to be issued later this year

CableLabs®

Summary

Evolving Cable Technology

- Cable is investing in delivering the best broadband experience possible
- DOCSIS 3.1 is the latest in the series that has evolved to meet anticipated future demand and facilitate new applications
  - It can cost-effectively scale to multi-gigabit speeds
  - It can work in and further optimize existing HFC plant
  - It defines options for new spectrum usage
  - It uses the latest modulation and FEC technologies



Usage and Adoption: What do Enterprise Customers Actually Buy?

Andrew M. Brown

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Technology Transitions Policy Task Force Workshop

Washington, DC March 18, 2013

The Services that Large Enterprise Customers Buy Today

- Data Services
  - MPLS is *the* standard for interstate and int'l networks
    - Class of Service (esp. critical for voice carried on the data network)
  - Access (DS1/DS3 and higher; Data Rings/SONET; Ethernet; ISDN PRI)
  - "Best Efforts" Internet access
- Voice
  - Local, LD, International minutes
  - Toll Free and associated features
  - Migrating toward convergence: SIP Trunking is how enterprises buy Interconnected VoIP
- Wireless
- Dark Fiber and DWDM
- Managed Services
- Hosted Services
- Cloud Computing, Applications and Application Development
- Unified Communications/Fixed Mobile Convergence

Common Characteristics of Large Enterprise Customers

- Footprint is regional, national or global
  - Multiple sites, varying in size
  - Geographically dispersed
- Technologically advanced but **highly** risk averse
  - Keen interest in constantly exploring new technologies
  - **But,** high premium on stability and proof of concept for any widely deployed network technology
  - Minimal to zero tolerance for service failures, disruptions, or speeds that are “lower than advertised”
- Large annual expenditures
  - Business requirements drive ongoing needs and demand for more services and more advanced technologies
  - **But,** intense pressure to reduce costs through competitive procurement or technology changes/improvements

Beyond Products and Technology

- Businesses buy more than products or technologies
  - Account support/sales teams
  - Support for complex billing
  - Service Level Agreements/minimum service requirements
  - New technology usually requires new internal support model

Trends that don't apply to the Enterprise Market

- "Cutting the Cord"
- Intermodal competition/substitution due to issues of:
  - Availability
  - Reliability
  - Scalability
  - Complexity

Trends that do apply to the Enterprise Market

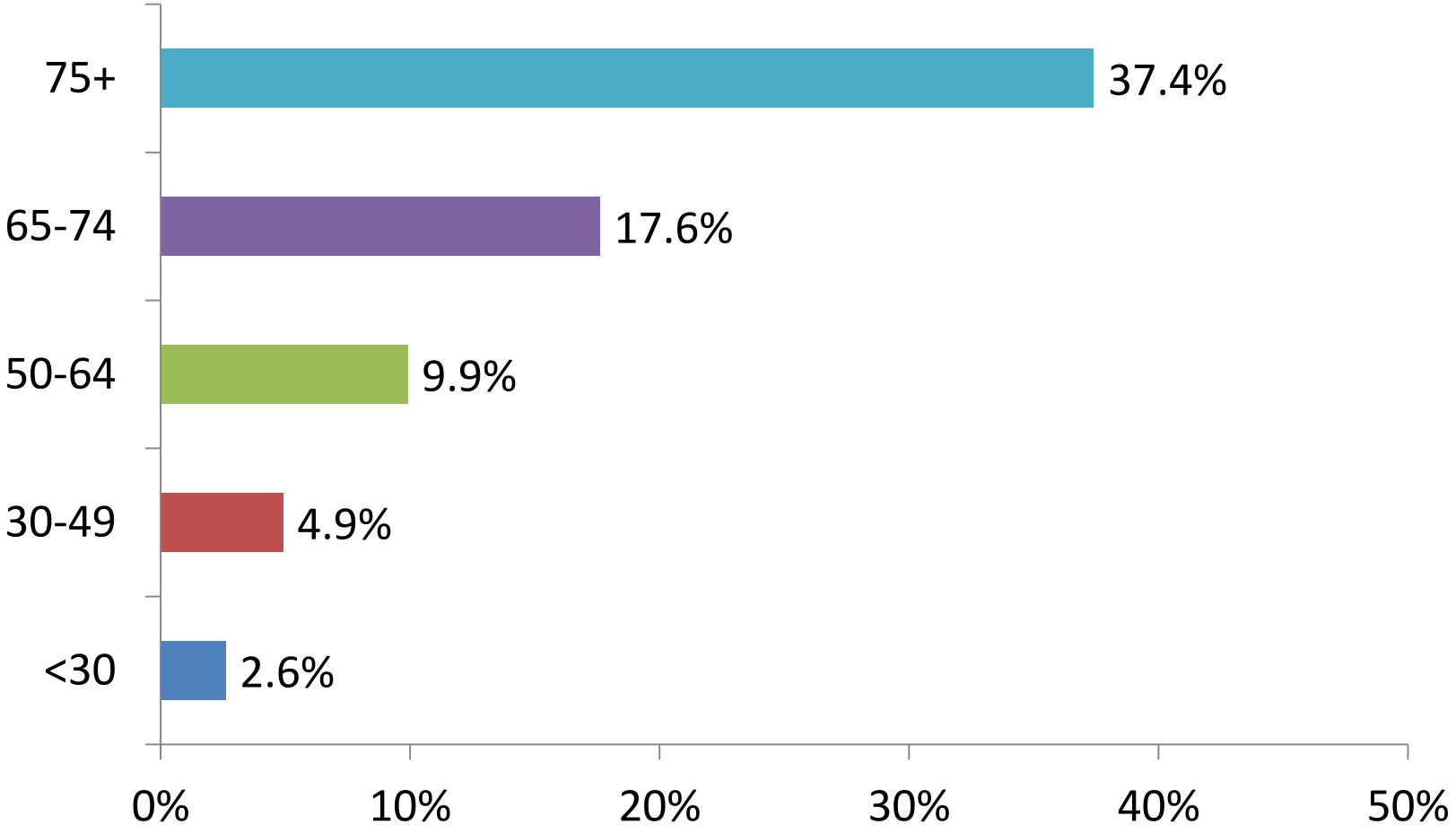
- Convergence of voice/data
- Network based services and apps
- Growth of wireless
- And, possibly, “consumerization” of services and pricing

Telecommunications Services and Older Adults

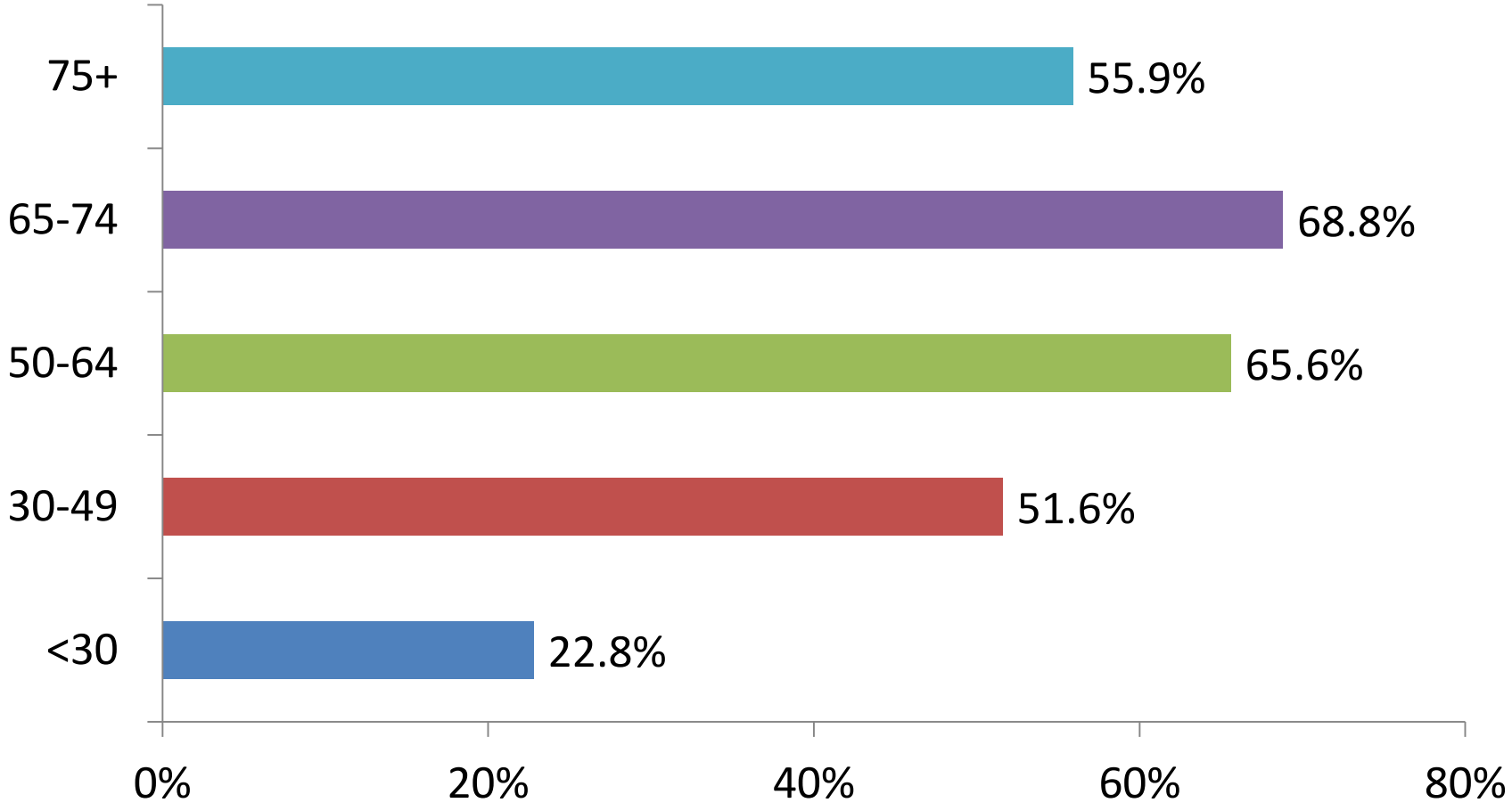
Presentation to the FCC Technology Transitions Task Force

Christopher Baker
AARP Public Policy Institute
March 18, 2013

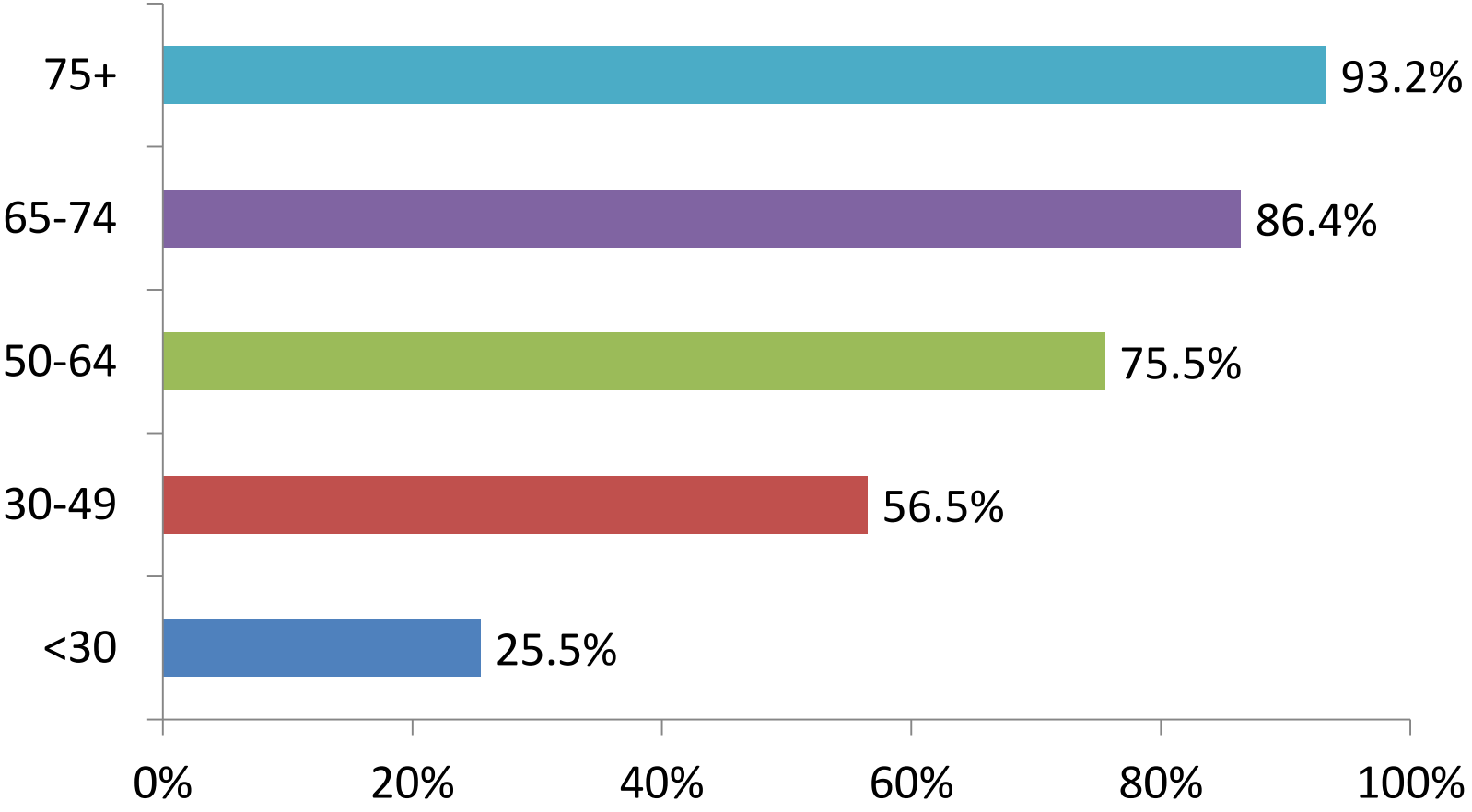
Wireline only households by age (2011 CDC-NHIS)



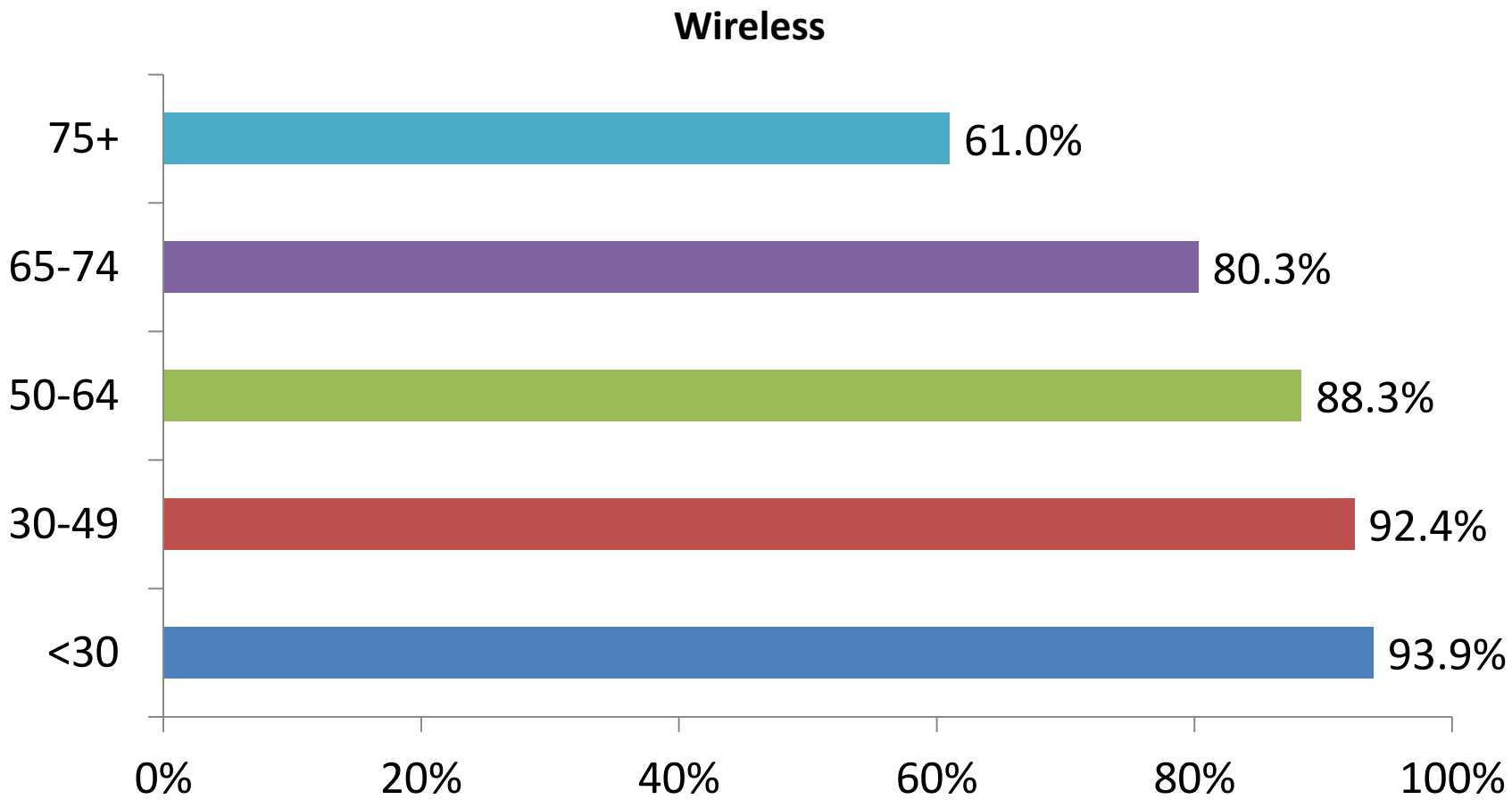
Households with wireline and wireless by age (2011 CDC-NHIS)



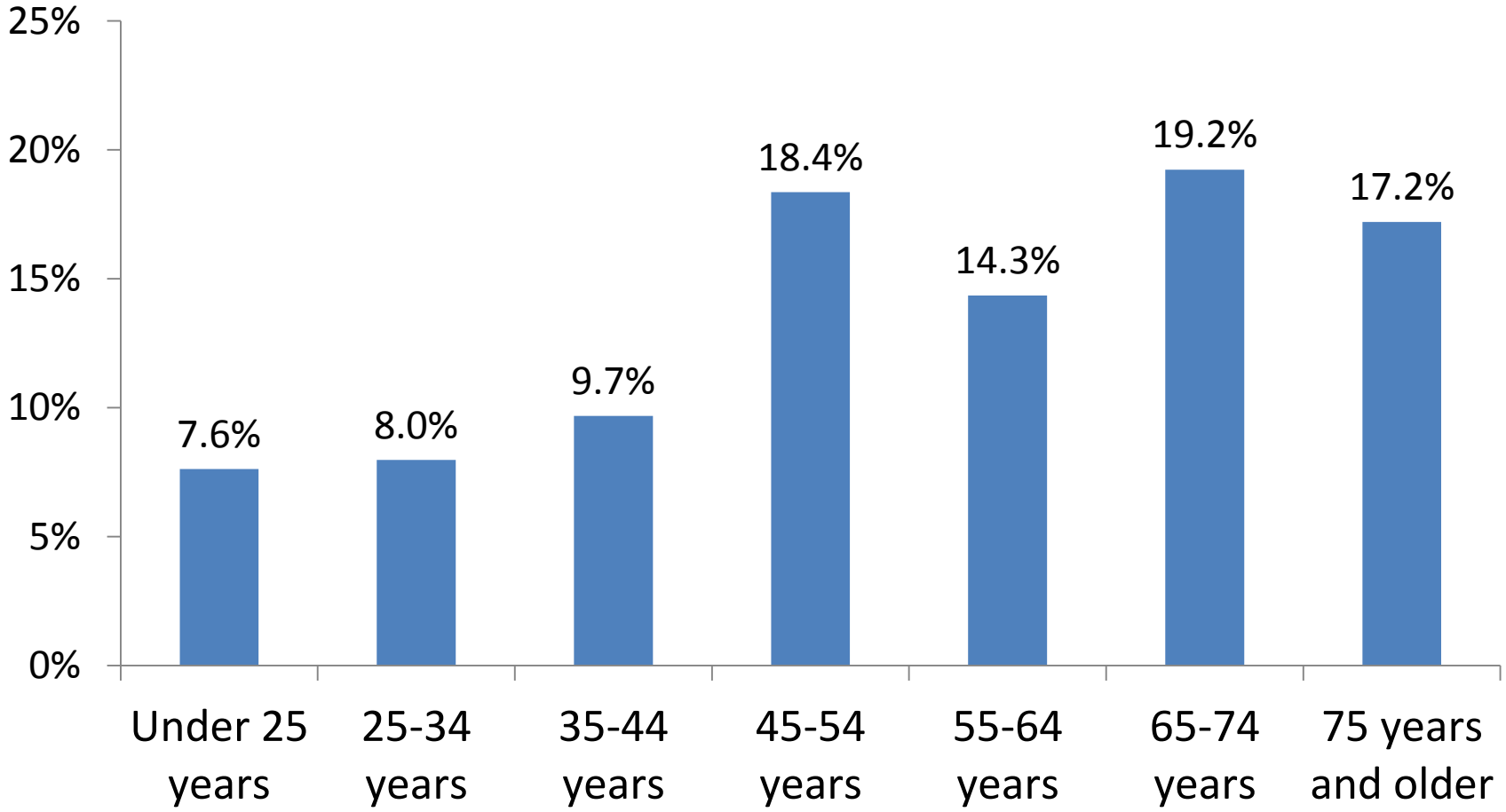
Households with wireline by age (2011 CDC-NHIS)



Households with wireless by age (2011 CDC-NHIS)



Percentage change in telephone expenditures by age (2006-2011)



Bureau of Labor Statistics, Consumer Expenditure Survey, 2006-2011.

Continuing value of wireline voice services

Reliable, high-quality voice service inside the home

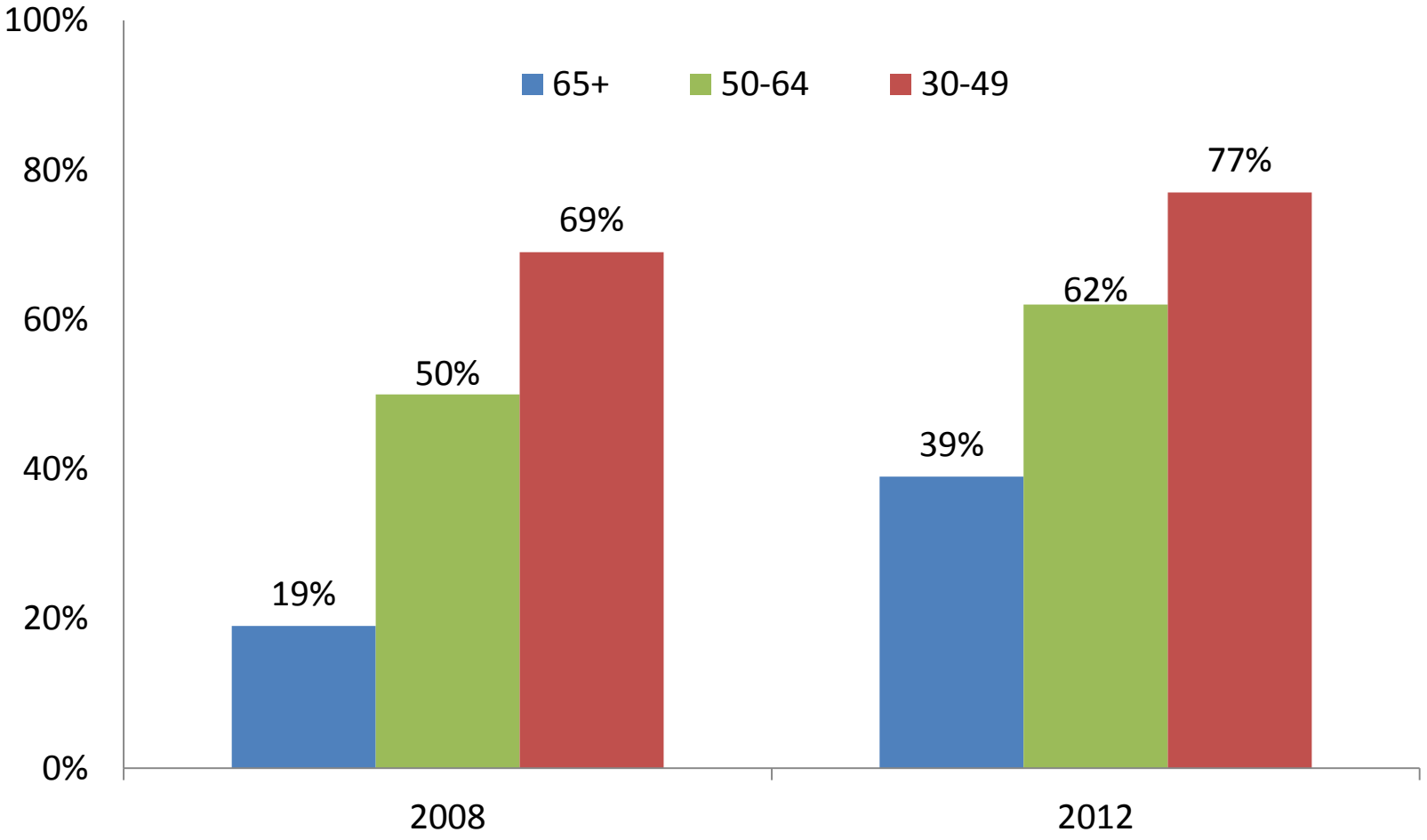
Unmetered local calling

Mobile phone problems

(2012 Pew Internet survey)

- Cell owners experience dropped calls:
  - 72% say at least occasionally
  - 32% say at least a few times a week or more frequently than that.
- 77% of cell internet users say they experience slow download speeds.
  - 46% of these users face slow speeds weekly or more frequently.

High-speed Internet at home, by age



Source: Pew Internet & American Life Project Surveys, April 2008 and April 2012.

Quality matters

Satisfaction with performance and reliability (on a 1,000-point scale):

- DSL customers: 650
- cable modem customers: 672
- fiber-to-the-home: 725

– JD Power 2012 U.S. Residential Internet Service Provider Satisfaction Study

Universally available, affordable and reliable communications services are as essential as ever for older adults.

Aging in place

Older adults overwhelmingly state that it is very important to have services available that allow them to age in place in their own homes for as long as possible (AARP).

Caregiver support

One in four older workers (age 45-64) are family caregivers. And the role of family caregivers has dramatically expanded to include performing medical/nursing tasks of the kind and complexity once provided only in hospitals (AARP).

Health preservation and monitoring

Falls are the leading cause of injury death for older Americans. One-third of Americans aged 65+ falls each year. (Center for Disease Control)

Greater opportunities to participate in society

Increasing opportunities online for paid work, continuing education, and volunteering

Growing share of Americans age 65+

(US Census Bureau)

- 1960 – One in 11 Americans
- 2010 – One in eight Americans
- 2030 – One in five Americans

Communications Technology Use in Communities of Color

A Presentation to the FCC Technology Transitions Task Force

Jessica J. González, Esq.
National Hispanic Media Coalition

March 18, 2013

Data Sources

- Pew Hispanic Center
- Pew Internet
- FCC Reports
- NTIA Reports
- U.S. Census
- Asian American Justice Center
- Center for Rural Strategies
- Joint Center for Political & Economic Studies
  -T. Morris & S. Meinrath, New Media Study
- Free Press Analysis of US National Health Interview Data
- News media
- Constituents

Basic Stats About People of Color

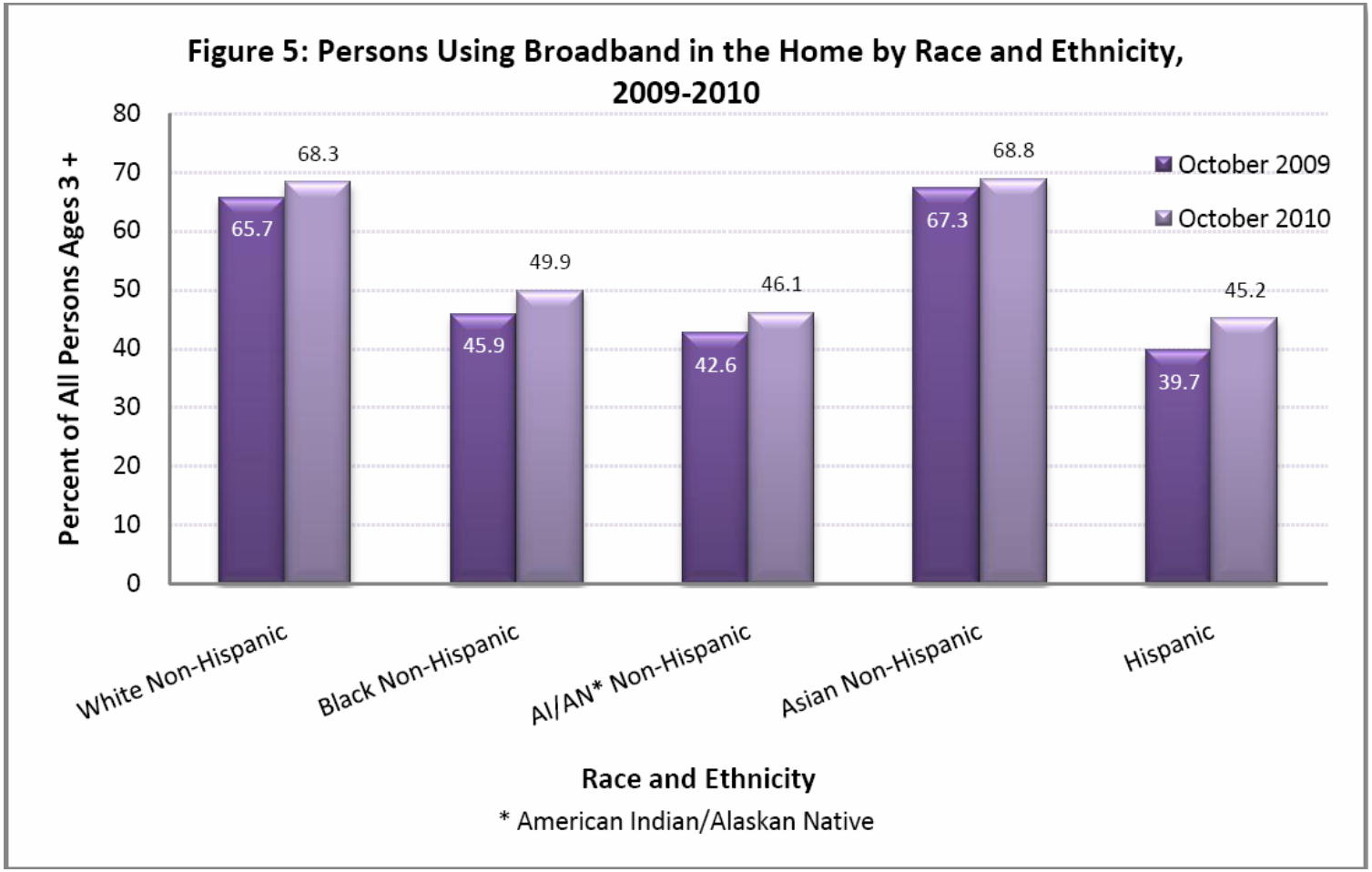
•308.7 million total people in the U.S. as of 2010

•Over 1/3 are people of color:

- •16.3% Latino/Hispanic
- •12.6% Black or African American
- •4.8% Asian American
- •.9% American Indian or Alaskan Native

•Rural areas are declining in their proportions of non-Latino whites, and are increasingly Latino, Asian American, African American and Native American

The Digital Divide Lives



•While not reflected here, significant disparities can exist among the sub-groups that make up a racial or ethnic category. FCC and NTIA data are gathered from English-only respondents.

•Chart comes from NTIA's Digital Nation, 2011. Note that there are disparities between the way the FCC and NTIA count broadband adoption and how other researchers have counted it.

Data Can Be Misleading

- Some data sets are gathered in English only, some in Spanish too, and none are collected outside of those two languages.
- Many data sets do not provide racial and ethnic breakdowns; others that do often leave out Native Americans and Asian Americans.
- There is not much available data on landline phone use by people of color.
- We need to exercise caution when using this data to identify and analyze trends, otherwise the most vulnerable portions of communities of color may be overlooked.

TABLE 2: PERCENTAGE OF HISPANICS USING THE INTERNET OR WITH HOME BROADBAND CONNECTIONS, 2009

	Internet Use	Home Broadband Connection
Hispanic	59%	47%
English-speaking	76	66
Spanish-speaking	34	21

Source: Joint Center for Political and Economic Studies, December 2009-January 2010. Based on 834 Hispanics.

Trends of the Unconnected

Table 6: Marginal Effects of Selected Demographic and Geographic Characteristics on the Likelihood that a Household Uses Broadband Internet at Home, 2009

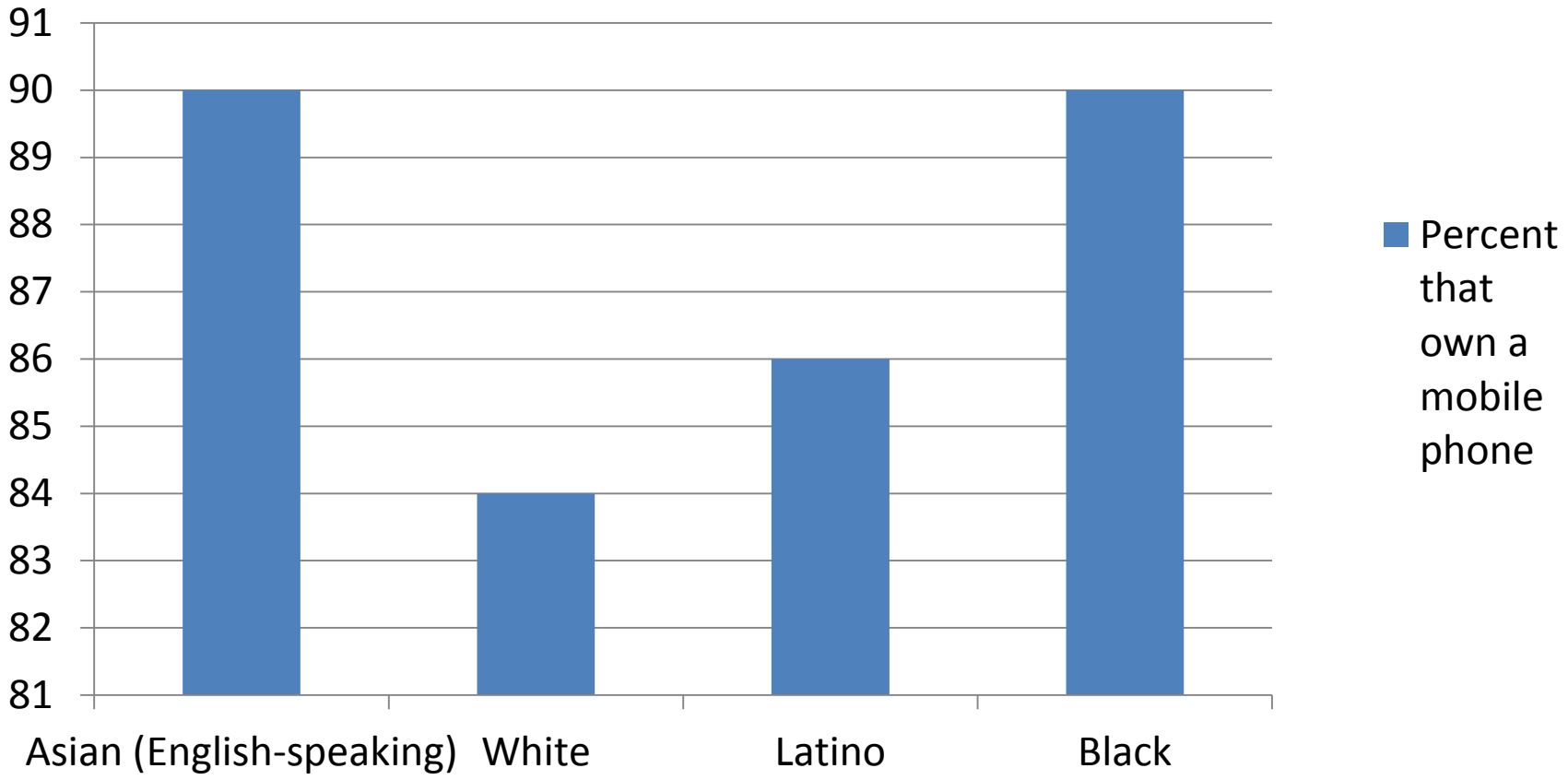
Adoption Gap: Difference in average broadband Internet adoption after controlling for demographic and geographic factors	
Household Characteristic	**Adoption Gap** (Percentage point)
Household Income	
Gap between households with incomes $25,000 to $50,000 and households with incomes less than $25,000	16
Gap between households with incomes $50,000 to $75,000 and households with incomes less than $25,000	27
Gap between households with incomes $75,000 to $100,000 and households with incomes less than $25,000	31
Gap between households with incomes more than $100,000 and households with incomes less than $25,000	34
Education	
Gap between those with a high school degree and those with less than high school degree	11
Gap between those with some college and those with less than high school degree	23
Gap between those with college degree or more and those with less than high school degree	29
Race and Ethnicity	
Gap between Non-Hispanic White and Non-Hispanic Black	10
Gap between Non-Hispanic White and Hispanic	14
Gap between Non-Hispanic White and Non-Hispanic Asian	0
Gap between Non-Hispanic White and Other*	5

Chart comes from NTIA's Digital Nation, 2011.

U.S. Territories – Home Broadband Starved

- 4.1 million people live in U.S. territories – nearly 4 million of them are in Puerto Rico alone
- 54% do not have broadband access at threshold speeds as defined by the FCC
- 85.2% people in rural parts of U.S. territories are without access
- % of people without broadband access: 78.6 in America Samoa; 100 in Northern Mariana Islands; 54.3 in Guam; 51.6% in Puerto Rico; 100 in U.S. Virgin Islands

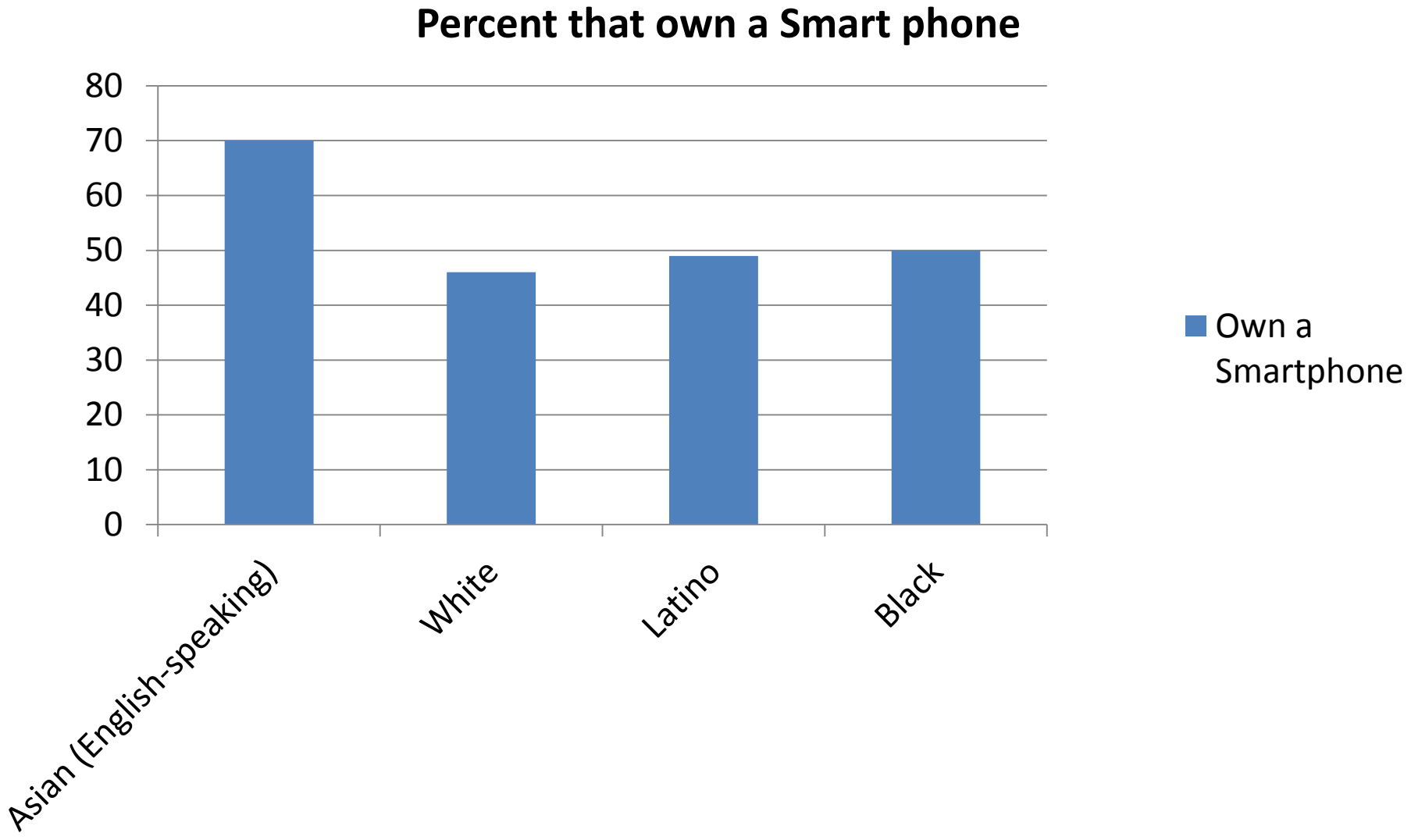
Much Ado About Mobile



Much Ado About Mobile

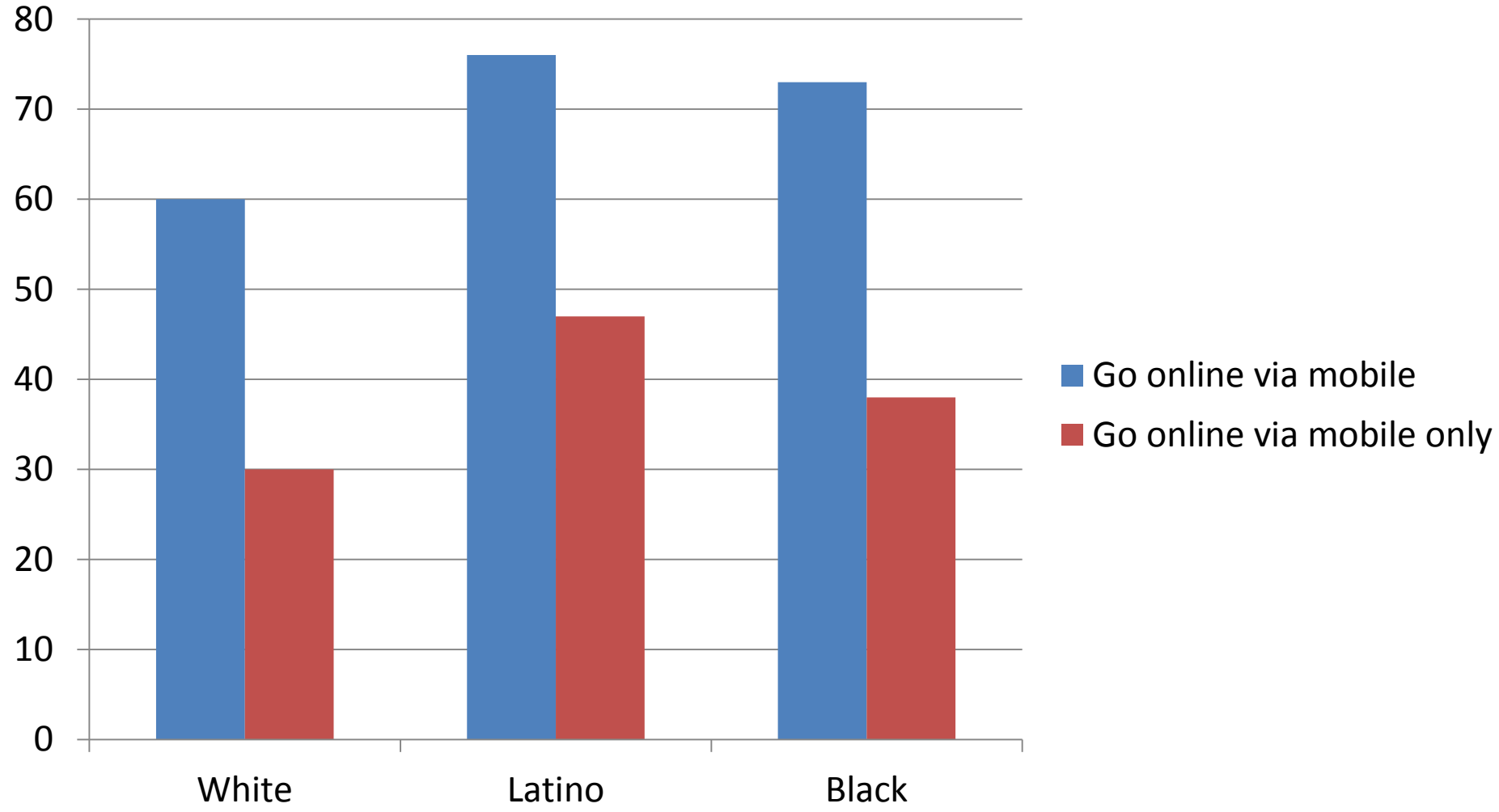
- About 34% of U.S. people do not have landlines and are in “cell-phone only” households.
  - 47% of Latinos
  - 38% of African Americans
  - 30% of whites
- At the same time, low income families (to which many people of color belong) are also more likely to rely on fixed line voice services or dial up internet access.
- Many people of color in rural areas rely on landline phones only because they do not have access to wireless services.
  - 14.5 million households in rural areas lack broadband access
  - Landline users in rural areas are starting to experience problems with call completion to wireless and VOIP connections.
- Today in 2013, some people of color in rural areas still do not even have access to landline telephone service.

Much Ado About Mobile

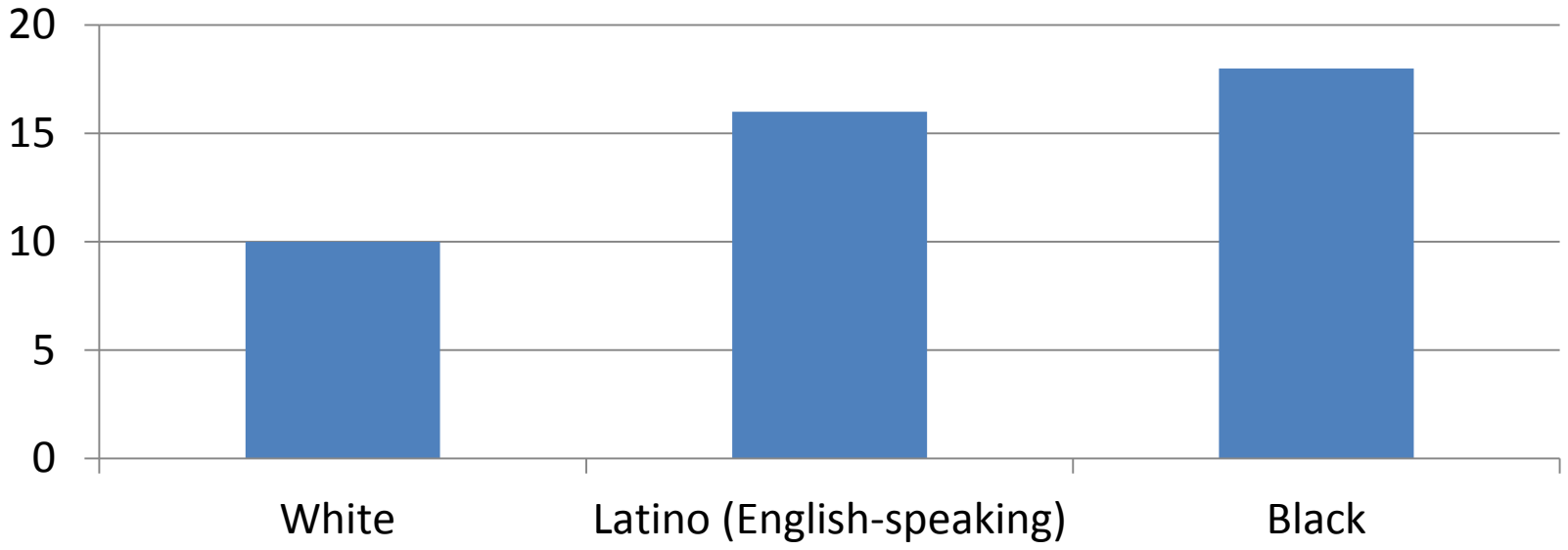


Much Ado About Mobile

Of people that go online, the following is a breakdown of whether they go online via mobile and whether their mobile device is their sole internet connection.



Mobile As Only Internet Onramp



Mobile only internet users are more likely to be poor and more likely to be black or Latino.

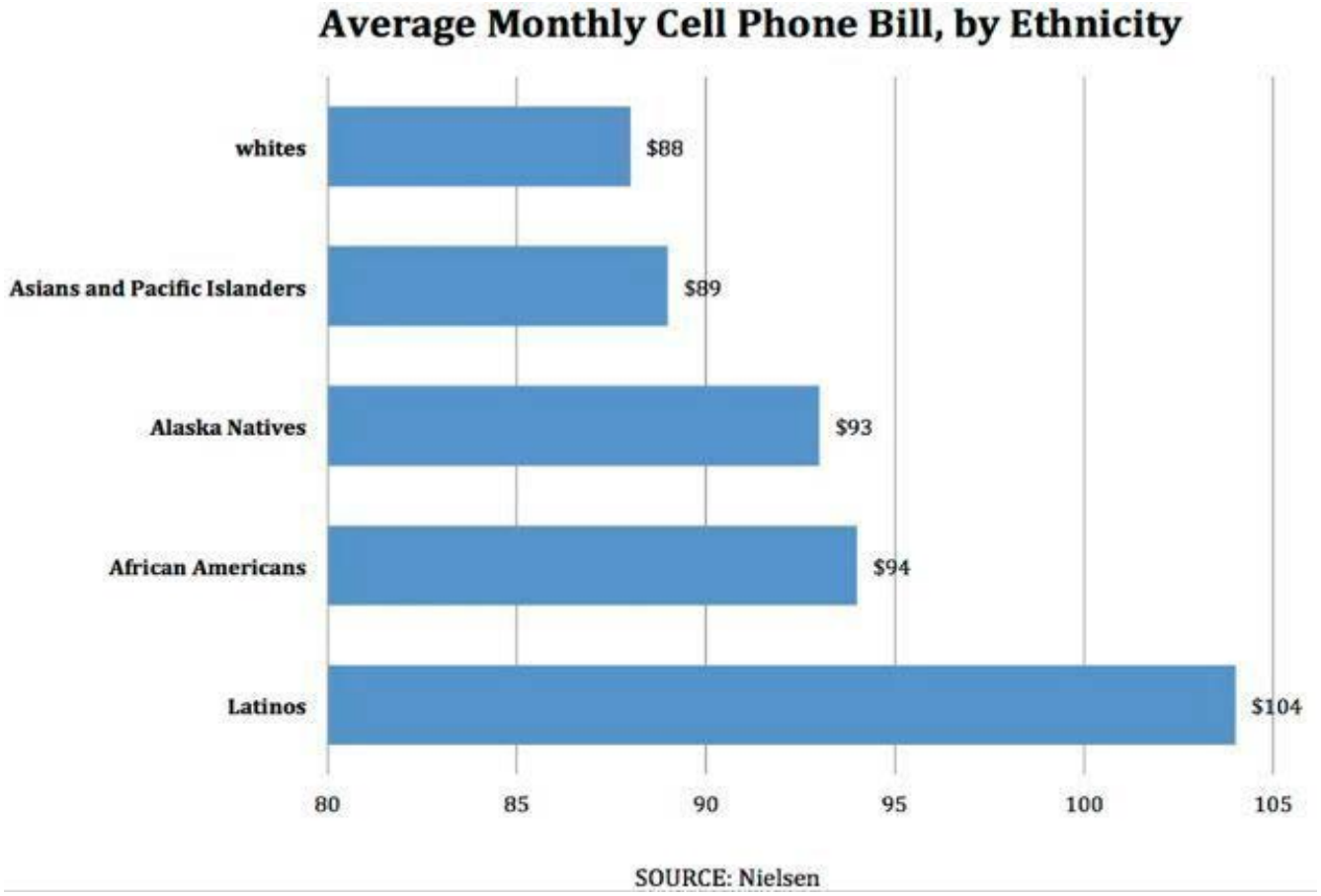
Mobile Is Not A Substitute for Home Broadband Connections

- Insufficient for:
  - Homework needs
  - Registering for classes or government services
  - Applying for jobs, financial aid, etc.
  - Online shopping and selling
  - Developing computer literacy skills
  - Civic engagement

- Obstacles include: data caps; mobile devices often do not have easy access to the entire internet (only about ¼ of US companies have enabled easy access); slower speeds; not universally available, especially in rural areas; cost

- Notably, mobile is arguably not a good substitute for landline telephones either based on mobile outages following recent devastating storms in the mid-Atlantic and Northeast.

People of Color Pay Higher Monthly Cell Bills Than Whites



In addition, people of color are more likely to use competitive carriers, like T-Mobile, Cricket, MetroPCS and others.

Trends of the Unconnected

In looking across various data sets pertaining to various technologies, there are certain traits that the least connected people of color often share:

- Poor
- Older
- Rural resident
-Tribal resident
- Disabled
- Born outside the U.S.
- Non-English dominant
- Less education
- U.S. territory resident

National Hispanic Media Coalition

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@NHMC

The Technologies Americans Use to Communicate

John B. Horrigan, PhD
Joint Center for Political & Economic Studies

March 2013

Plan for today

- Look at data on how people communicate … by phone, using broadband networks
- Examine patterns in demographic groups
- Data:
  - Centers for Disease Control
  - Pew Internet 2012 survey
  - FCC 2011 Form 477 report (January 2013 WCB)
  - NTIA 2010 data
  - FCC 2009 survey

High level overview of tech usage trends I
(business & residential)

- Mobile subscriptions:
  - 261m in 2008 → 298m in 2011
- Interconnected VoIP
  - 21.7m in 2008 → 36.7m in 2011
- Retail switched access lines:
  - 141m in 2008 → 107m in 2011

High level overview of tech usage trends II

(among individuals)

	Cell Phone	Internet Use	Broadband at home	Smartphone
1998	37%	36%	n/a	n/a
2000	53	50	3	n/a
2003	65	61	16	n/a
2006	73	70	42	n/a
2009	82	74	63	17
2012	88	81	66	45

Wireline at home

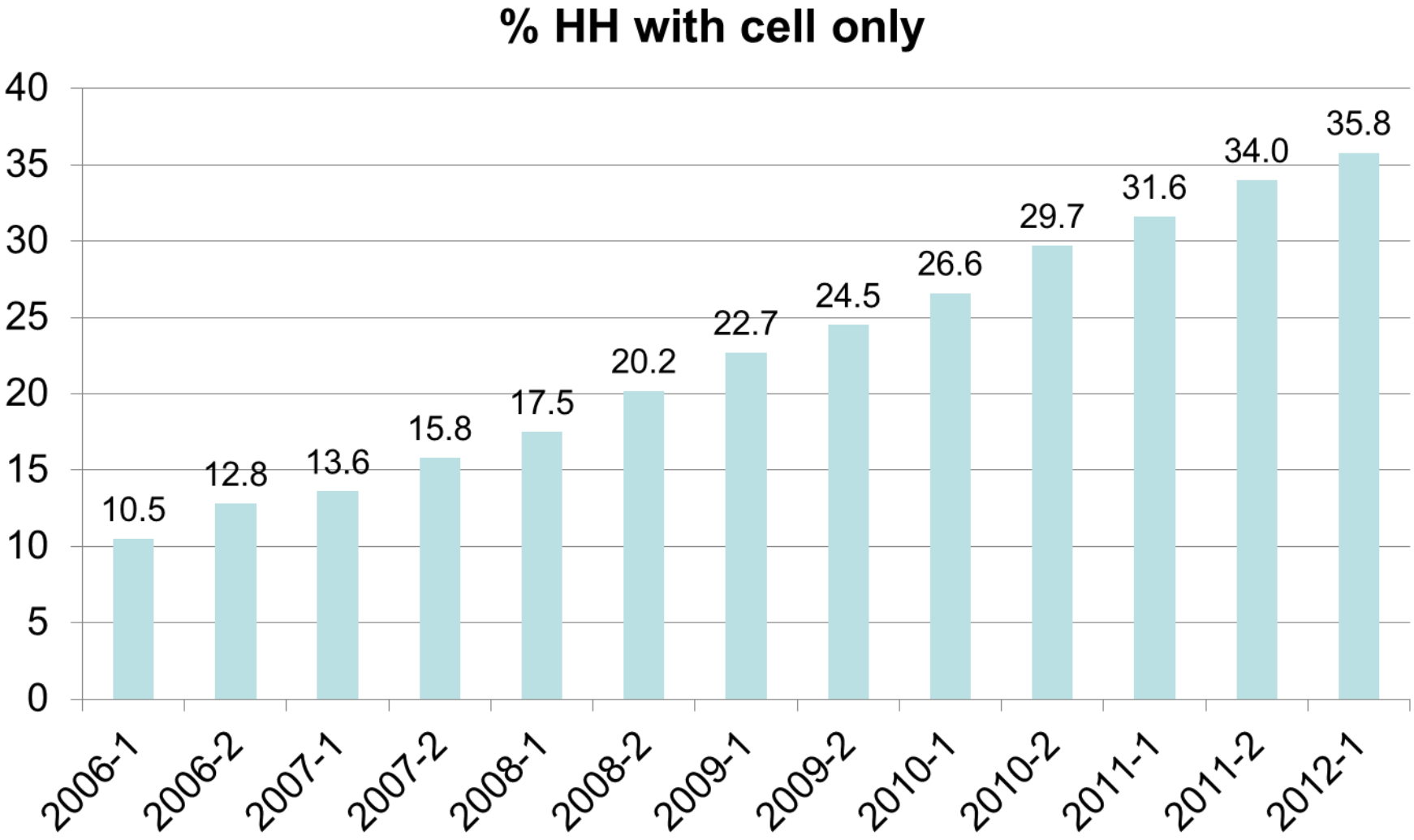
(End-user switched access & VoIP, residential, FCC 2011)

- 83m lines in 2011 vs 97.8m in 2008
  - 37.2% VoIP in 2011 vs 20.1% in 2008

	End User Switched Access Lines (in millions)	VoIP Subscriptions (in millions)
Dec 2008	78.2	19.7
June 2009	73.1	20.3
Dec 2009	68.6	22.8
June 2010	64.5	25.0
Dec 2010	60.0	27.0
June 2011	56.0	28.6
Dec 2011	52.1	30.9

- 86% of residential VoIP is non-ILEC in 2011

Trends in “Cell Only” Households (Centers for Disease Control data)



How Americans make phone calls

(CDC Jan 2012 data for households)

- 52.5% have landline and wireless
  - 58.5% in 2008
- 9.4% have landline only
  - 20.6% in 2008
- 35.8% are cell phone only
  - 17.5% in 2008

“Cell only” by Race

Race	Avg=10.5% 2006-1	Avg=22.7% 2009-1	Avg=35.8% 2012-1
White (non-Hispanic)	9.0	19.7%	30.4%
Black (non-Hispanic)	10.5	21.3	37.7
Hispanic or Latino (any race)	11.2	28.2	46.5

“Cell only” by Age

Age	Avg=10.5% 2006-1	Avg=22.7% 2009-1	Avg=35.8% 2012-1
18-24 years	22.6%	37.6%	49.5%
25-29 years	22.3	45.8	60.1
30-34 years	12.1	33.5	55.1
35-44 years	8.2	21.5	39.1
45-64 years	5.3	12.8	25.8
65 and over	1.3	5.4	10.5

“Cell only” by Poverty Status

Status	Avg=10.5% 2006-1	Avg=22.7% 2009-1	Avg=35.8% 2012-1
Poor	15.8%	33.0%	51.8%
Near Poor	14.4	26.5	42.3
Not Poor	9.4	18.9	30.7

Broadband Adoption Overview
(NTIA 2010 Data)

- 68% of homes have broadband
- Connection types (% of all households):
  - 32% cable modem
  - 23% DSL
  - 9% Internet use outside the home
  - 6% mobile broadband only or with other internet services
  - 3% fiber optics
  - 3% dial-up
  - 2% satellite
  - 2% other broadband
  - 20% non-Internet users

Broadband: Urban v. Rural

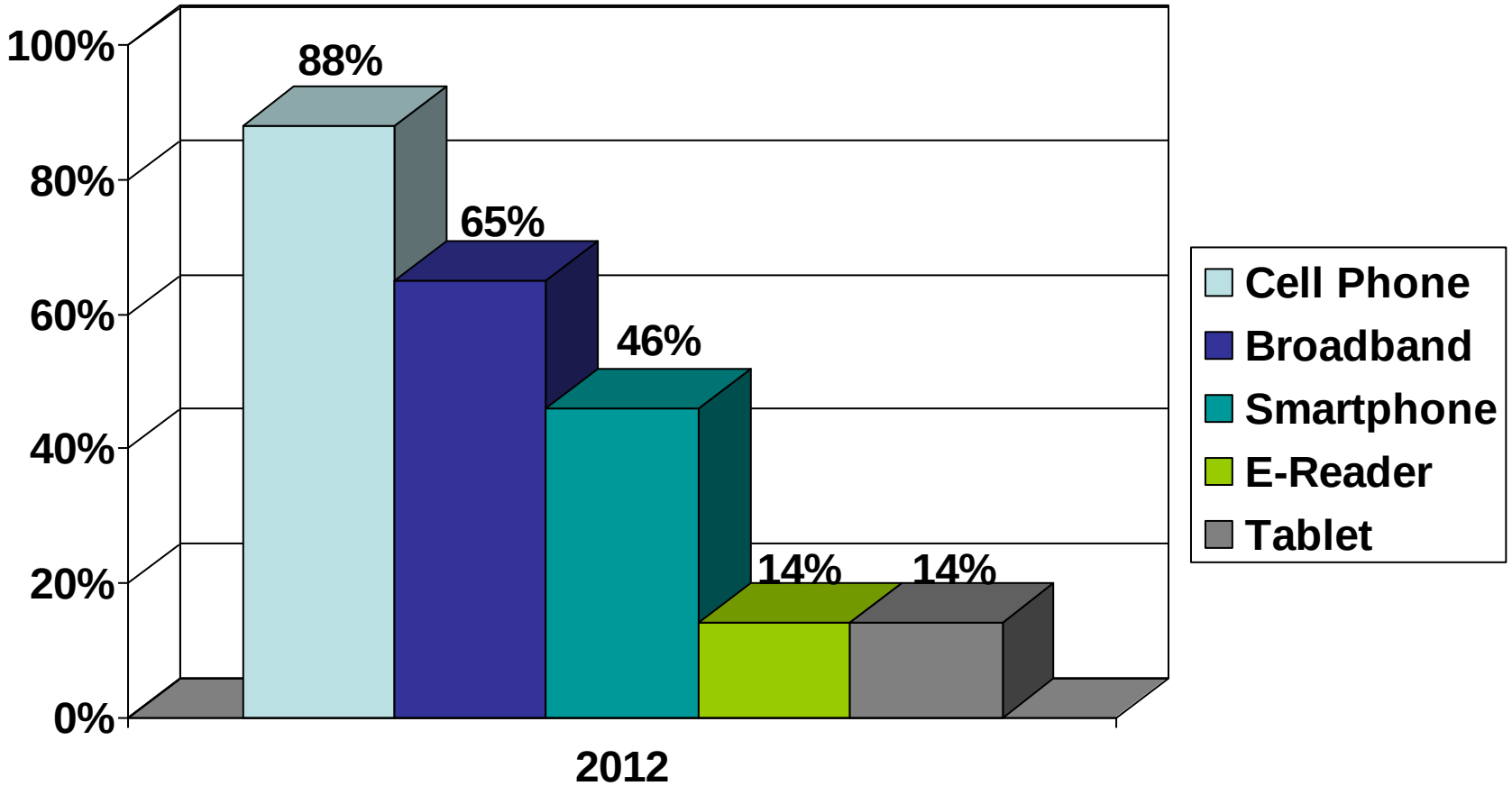
(NTIA 2010 Data)

- 70.3% urban households with broadband
- 60.2% of rural households with broadband

	Urban Connection Type	Rural Connection Type
Cable modem	35%	19%
DSL	23	27
Outside the home	9	11
Mobile only	7	6
Satellite	1	3
Other	2	1
Dial-up	2	5
Non-Internet HH	18	28

Overview: Device & Service Use I

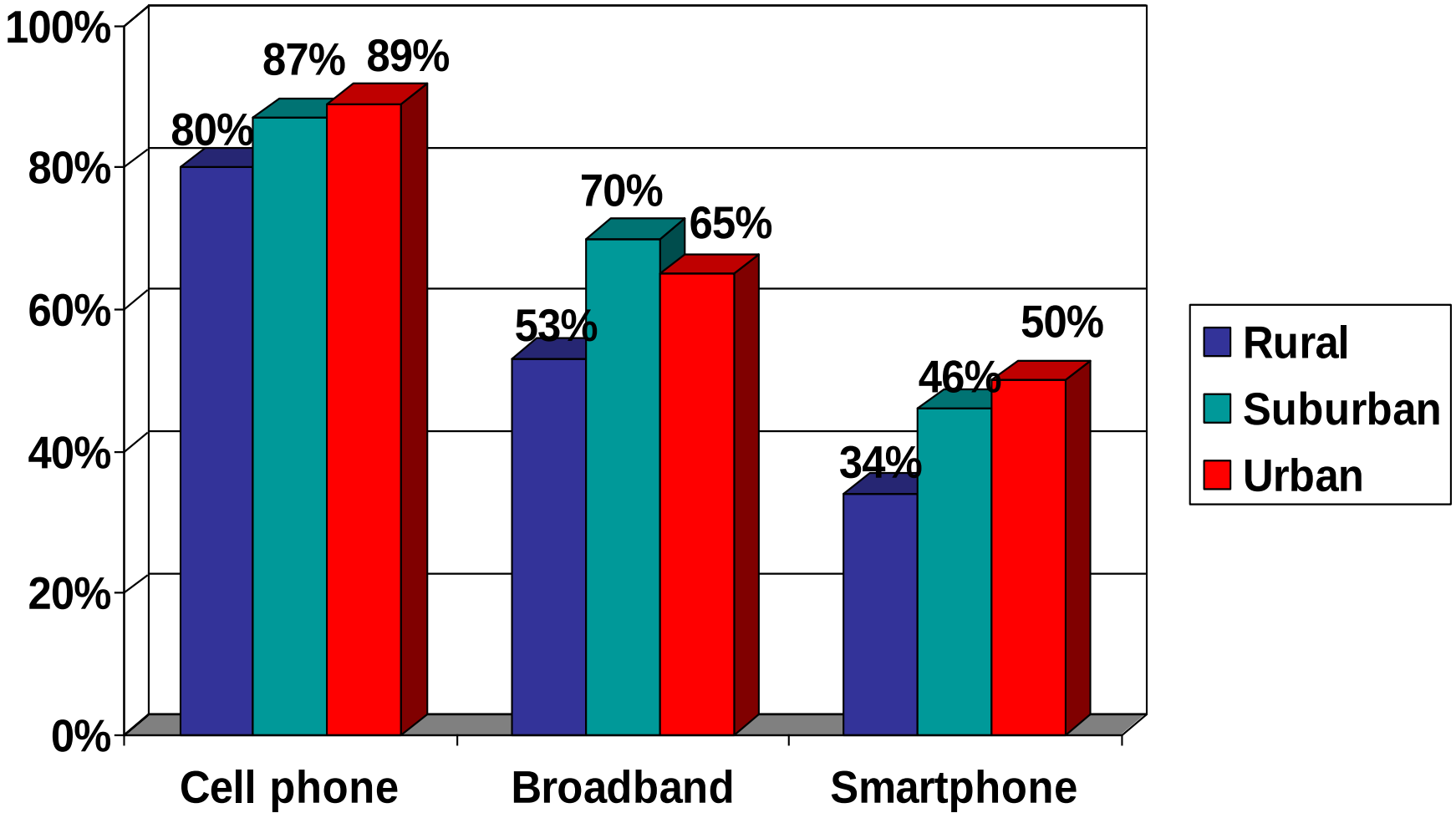
(All Adults – Pew 2012 data)



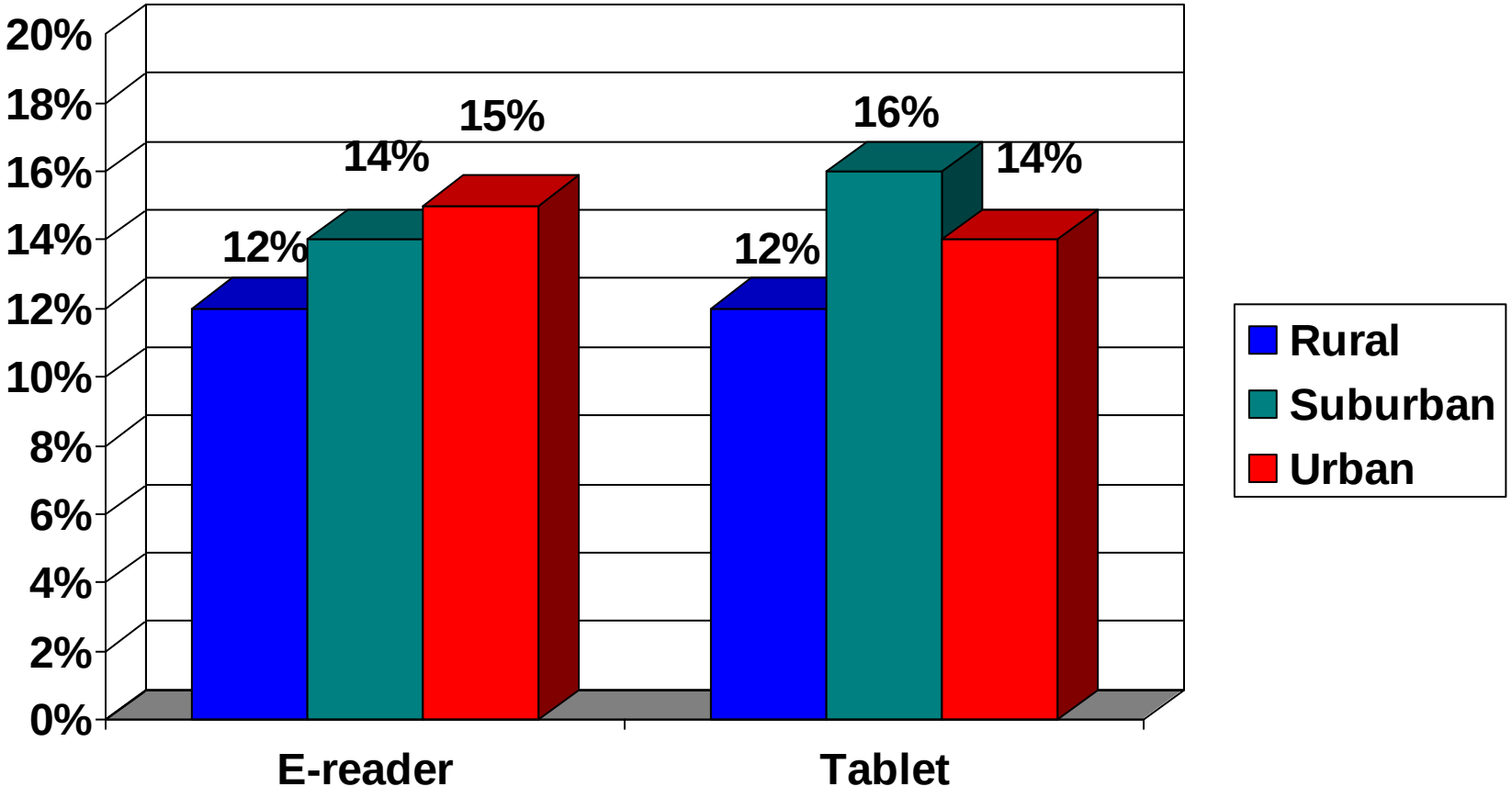
Overview: Device & Service Use II
(Teens, age 12 to 17, Pew Sept 2012 data)

- 78% of teens have a cell phone
- 37% of teens have a smartphone
  - Up from 23% in 2011
- 23% of teens have a tablet computer
- On usage:
  - 93% have a computer or access to it
    - 71% share the computer they use with someone
  - 74% access the Internet on cell phones, tablets, or other mobile devices
  - 25% of teens are “cell-mostly” Internet users
    - 15% of adults are “cell-mostly” Internet users
    - Among teens with smartphones, half are “cell mostly” Internet users.

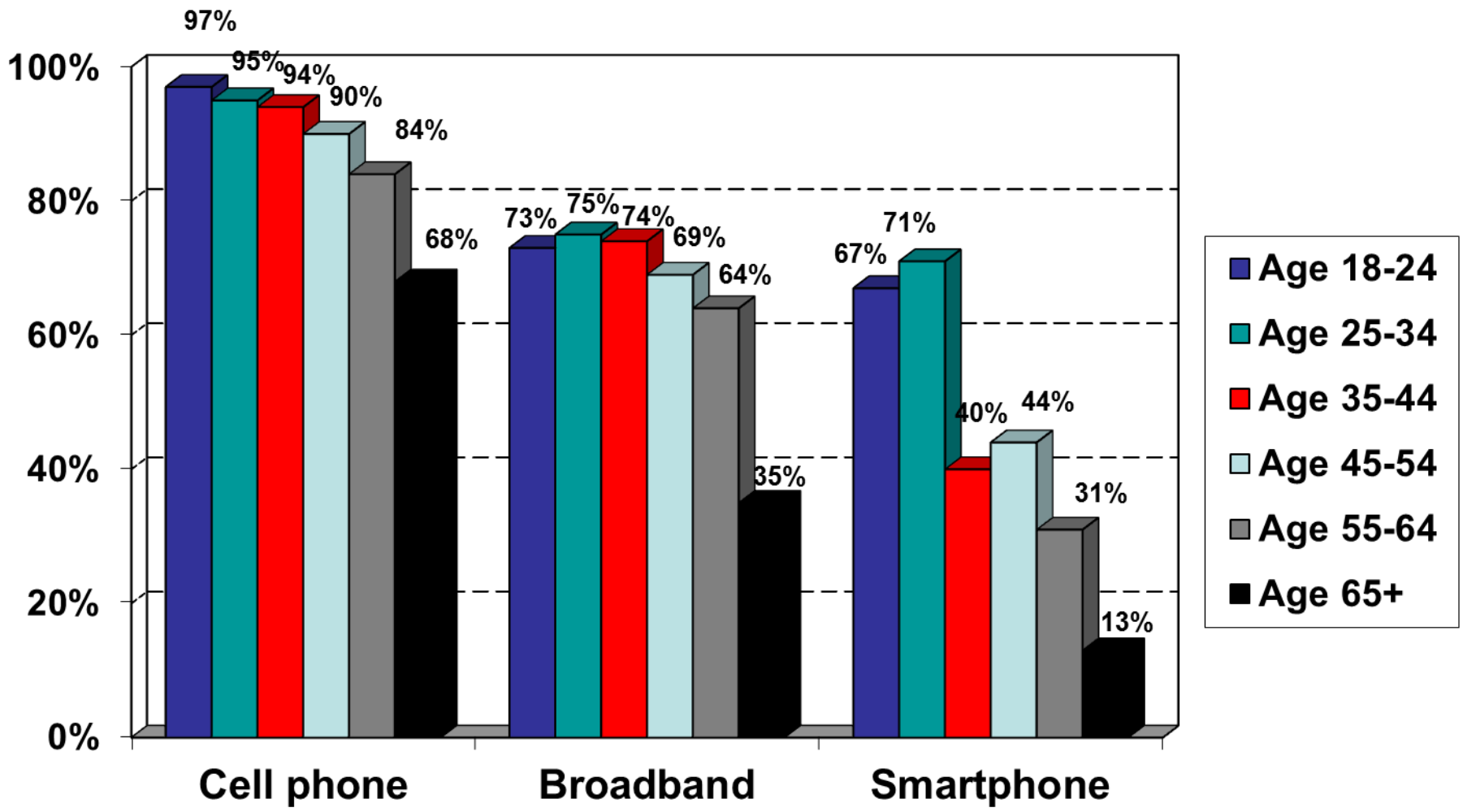
Rural: Services



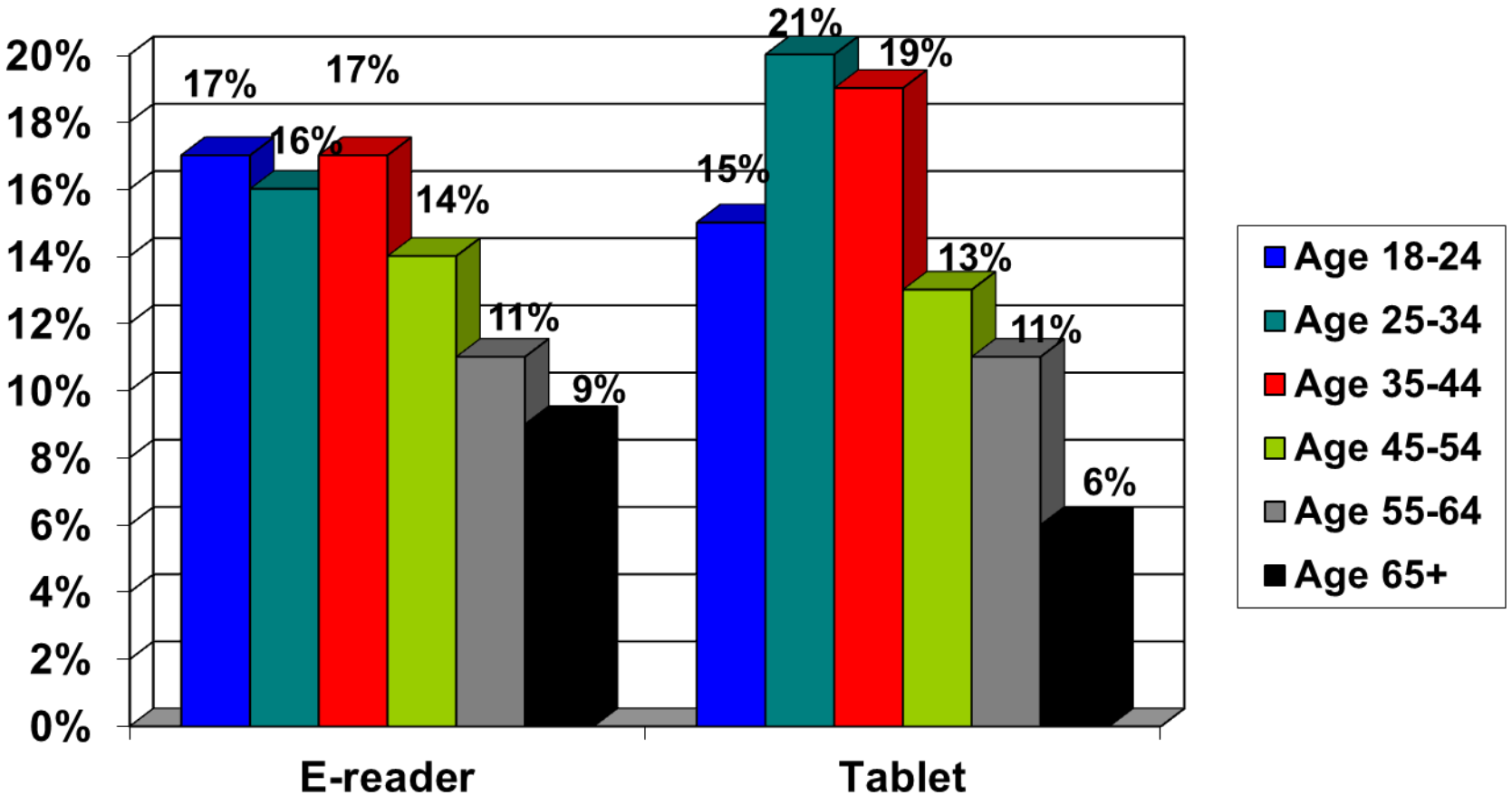
Rural: Devices



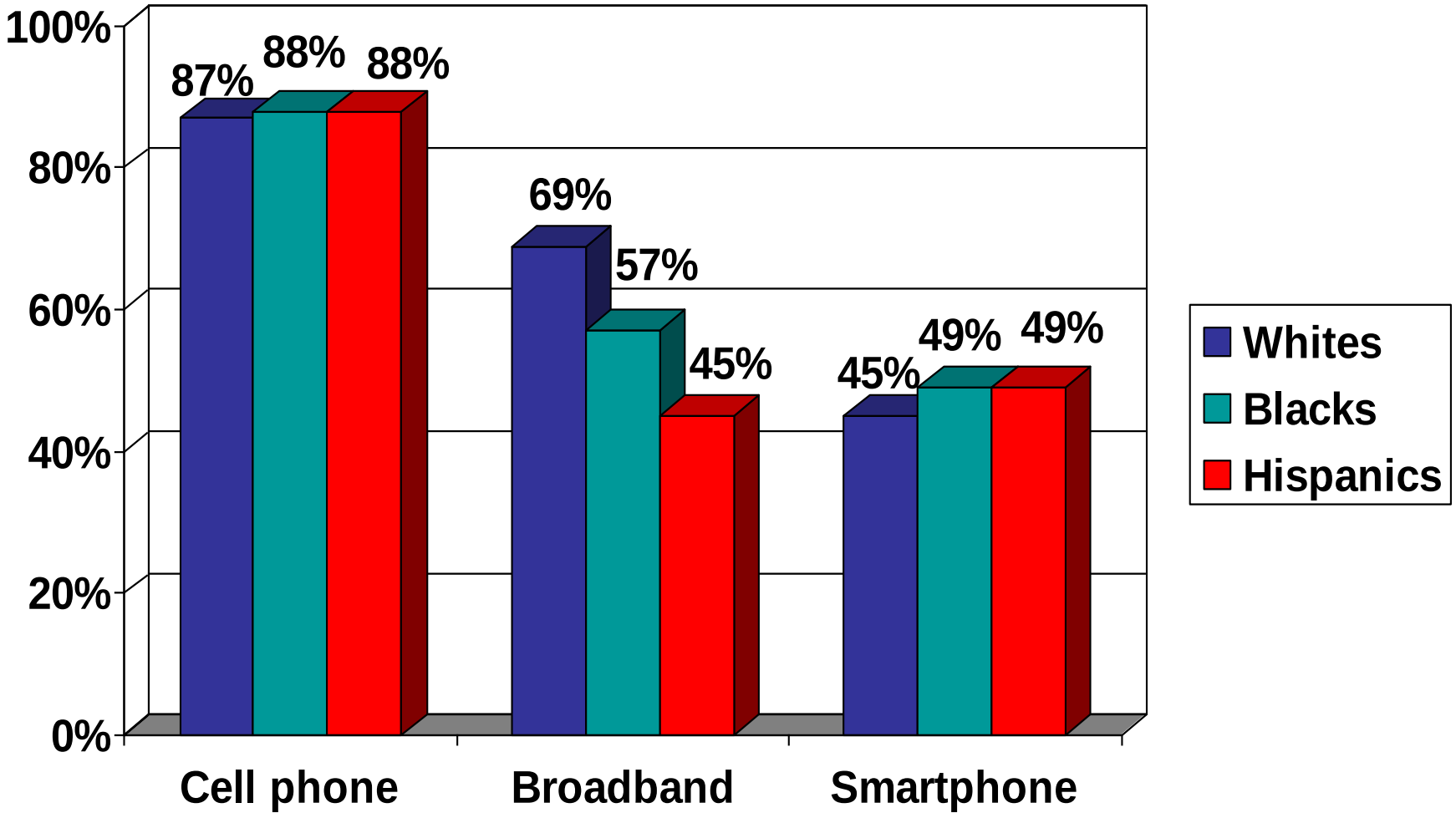
Age: Services



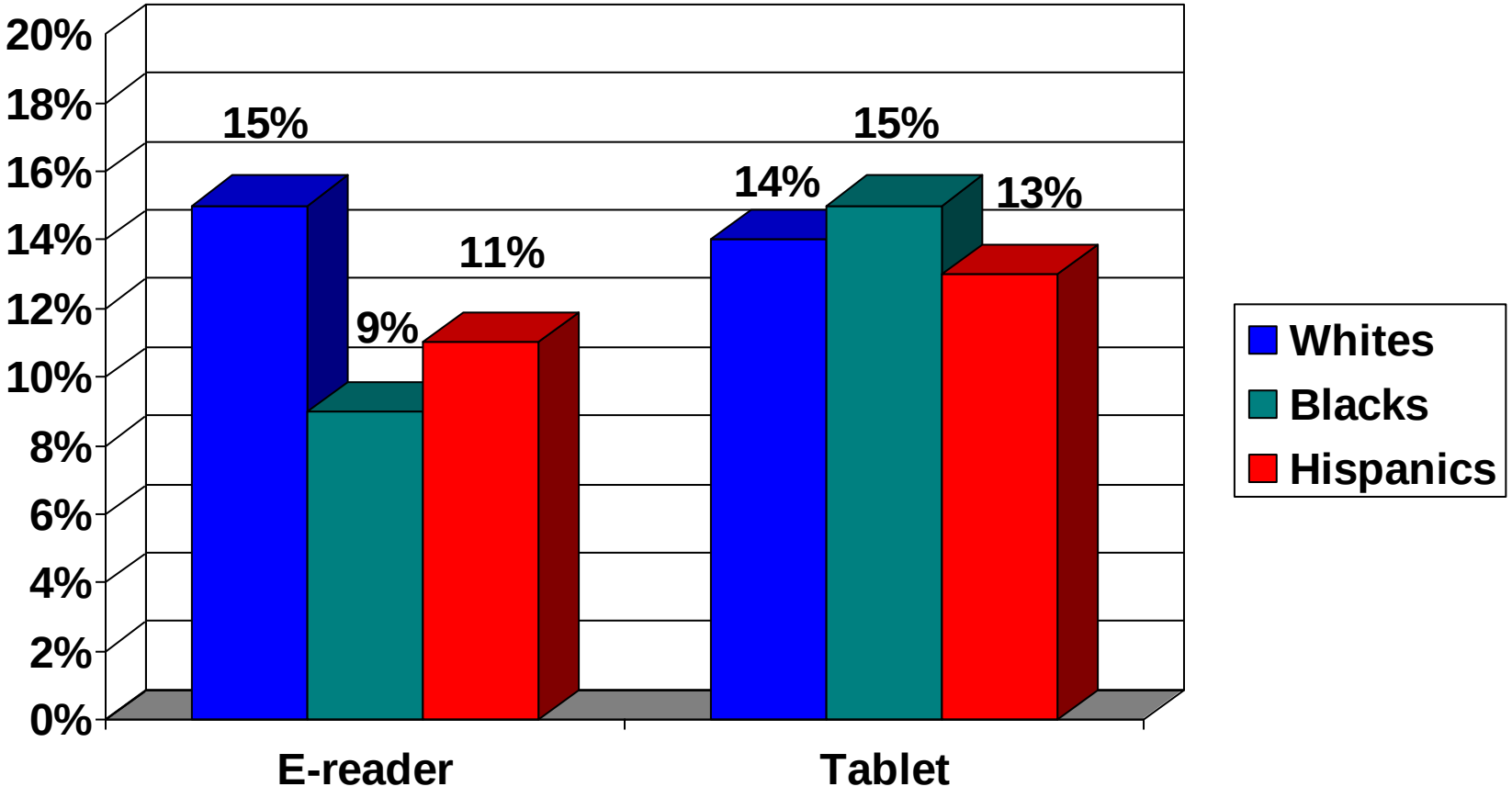
Age: Devices


20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
17%
16%
17%
14%
11%
9%
15%
21%
19%
13%
11%
6%
E-reader
Tablet
Age 18-24
Age 25-34
Age 35-44
Age 45-54
Age 55-64
Age 65+

By Race: Services

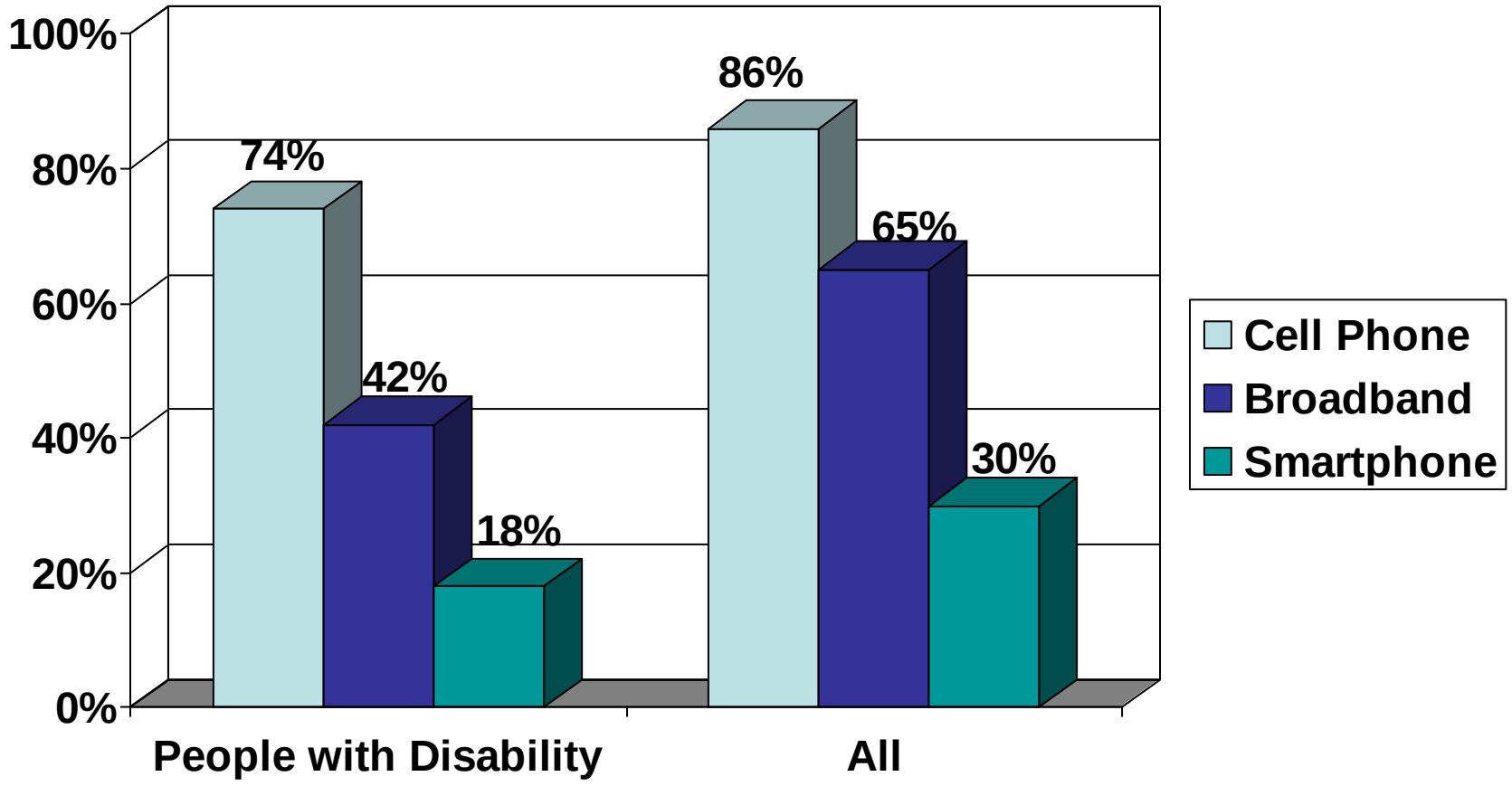


By Race: Devices



People with Disabilities

(2009 FCC Survey)



Broadband at home by Disability Status (NTIA 2010)

- 37.5% of all people with disabilities have broadband at home

Type of Disability	% using broadband at home
Difficulty dressing/bathing	27.9%
Deaf/difficulty hearing	36.5
Blind/difficulty seeing	30.7
Difficulty doing errands	27.8
Difficulty walking or climbing stairs	33.7
Difficulty concentrating/remembering	35.3

What about the relationship between Smartphones & Broadband?

(Pew Feb 2012 data)

- For those with broadband at home:
  - 83% have a Smartphone
  - 19% have an e-reader
  - 21% have a tablet
- For those without broadband at home:
  - 8% have a Smartphone
  - 4% have an e-reader
  - 2% have a tablet
- For blacks without broadband at home:
  - 13% have a Smartphone
- For Hispanics without broadband at home:
  - 19% have a Smartphone
- For seniors without broadband at home:
  - 4% have a Smartphone

Overall wireless use:

63% of adults have gone online wirelessly using some device

- 88% of 18-29 year olds have connected wirelessly
  - 21% of 65+ have.
- 86% of those in over $75K annual income households have connected wirelessly
  - For under $30K HH, 50% have
- Race/ethnicity breakout:
  - 63% of whites have gone online wirelessly
  - 62% of blacks (non-Hispanics) have
  - 63% of Hispanics

Rural Broadband Internet Subscriptions

Peter Stenberg

Economic Research Service

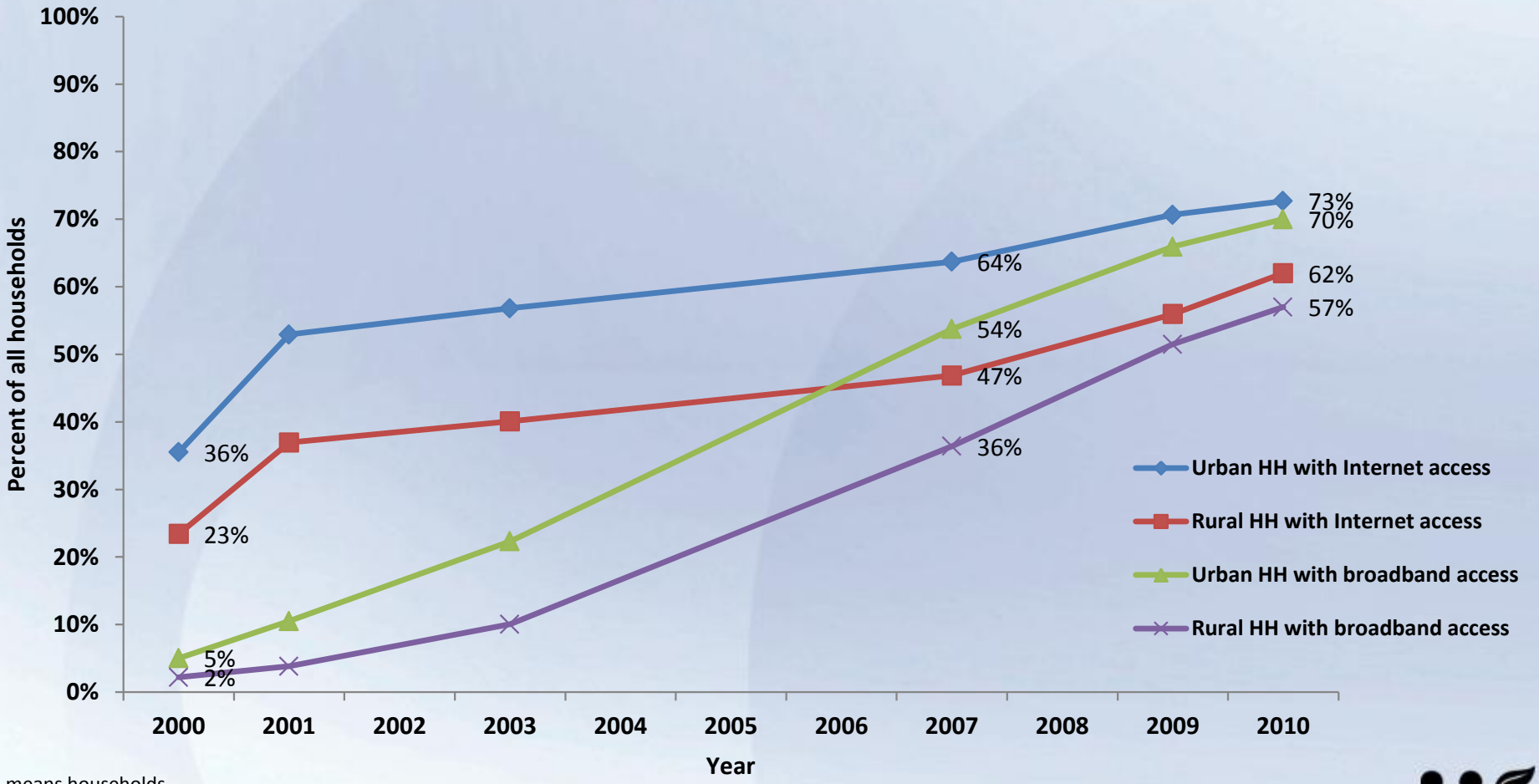
Presented at the Federal Communication Commission Technology Transitions Workshop, March 18, 2013.

Introduction

- Internet has become widely, but not universally, available
- Not all, voluntarily or involuntarily, choose to use

Internet subscriptions, including broadband, increased dramatically

Fig. 1 Households with Internet Subscriptions, 2000-2010



HH means households.

Source: ERS using Census data.

Broadband subscription rates across the country vary greatly across the country

Figure 2: Urban Households with Broadband Internet subscriptions, 2010

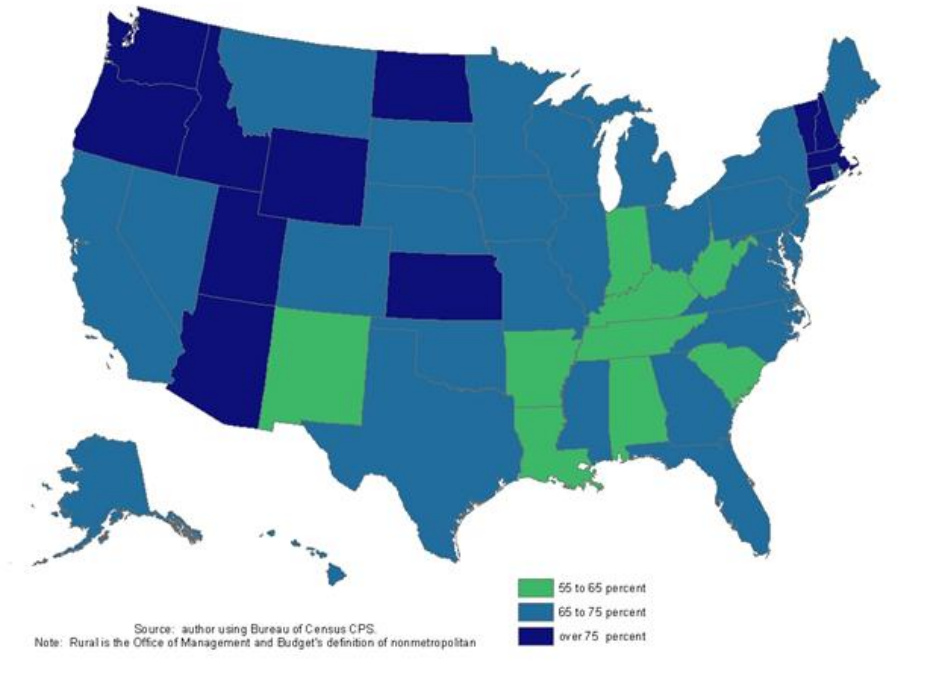
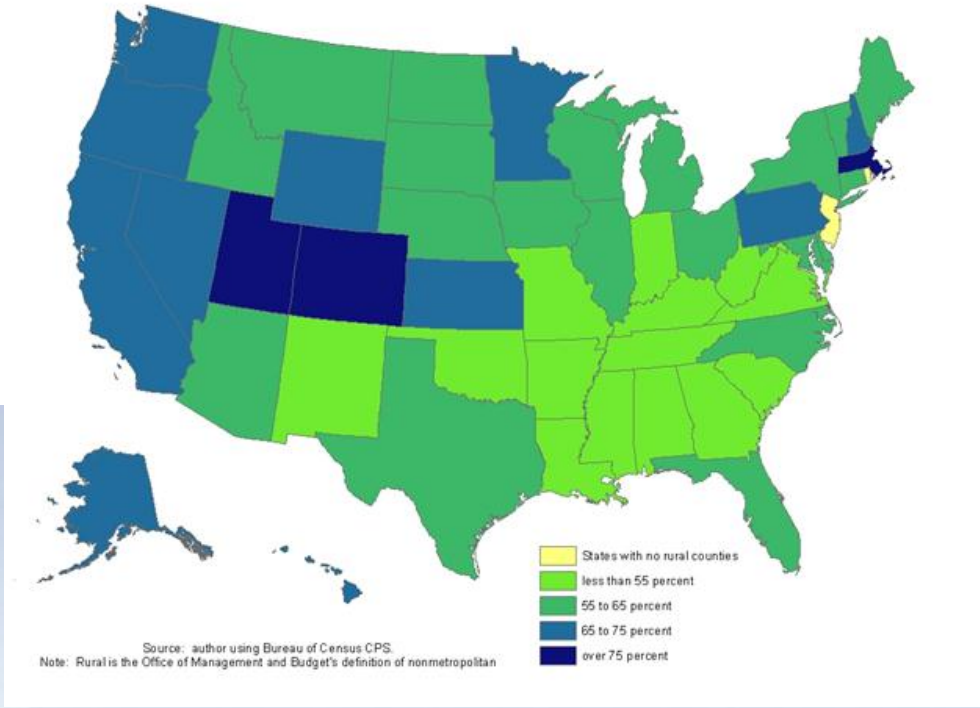
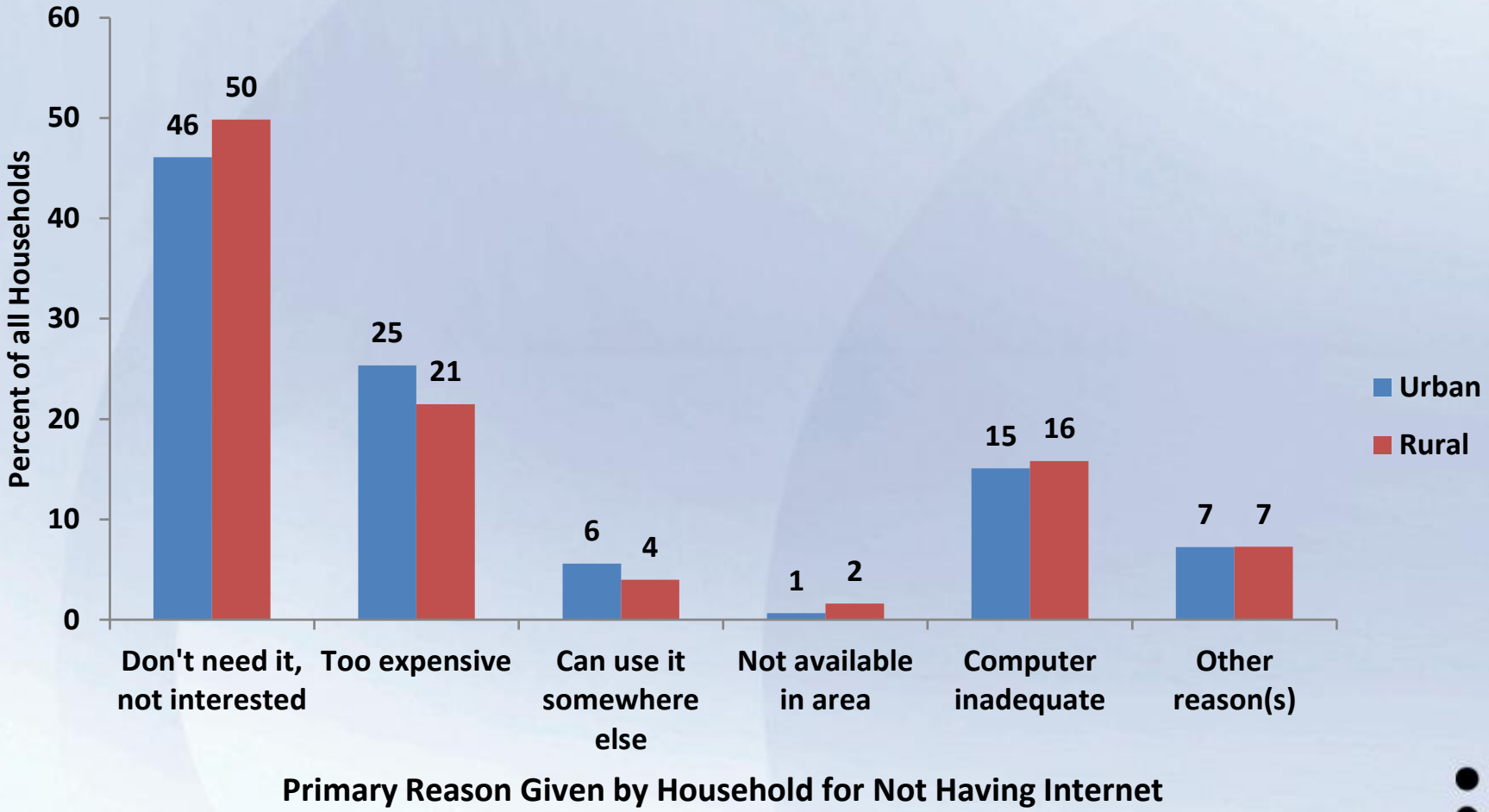


Figure 3: Rural Households with Broadband Internet subscriptions, 2010



Why households don't subscribe?

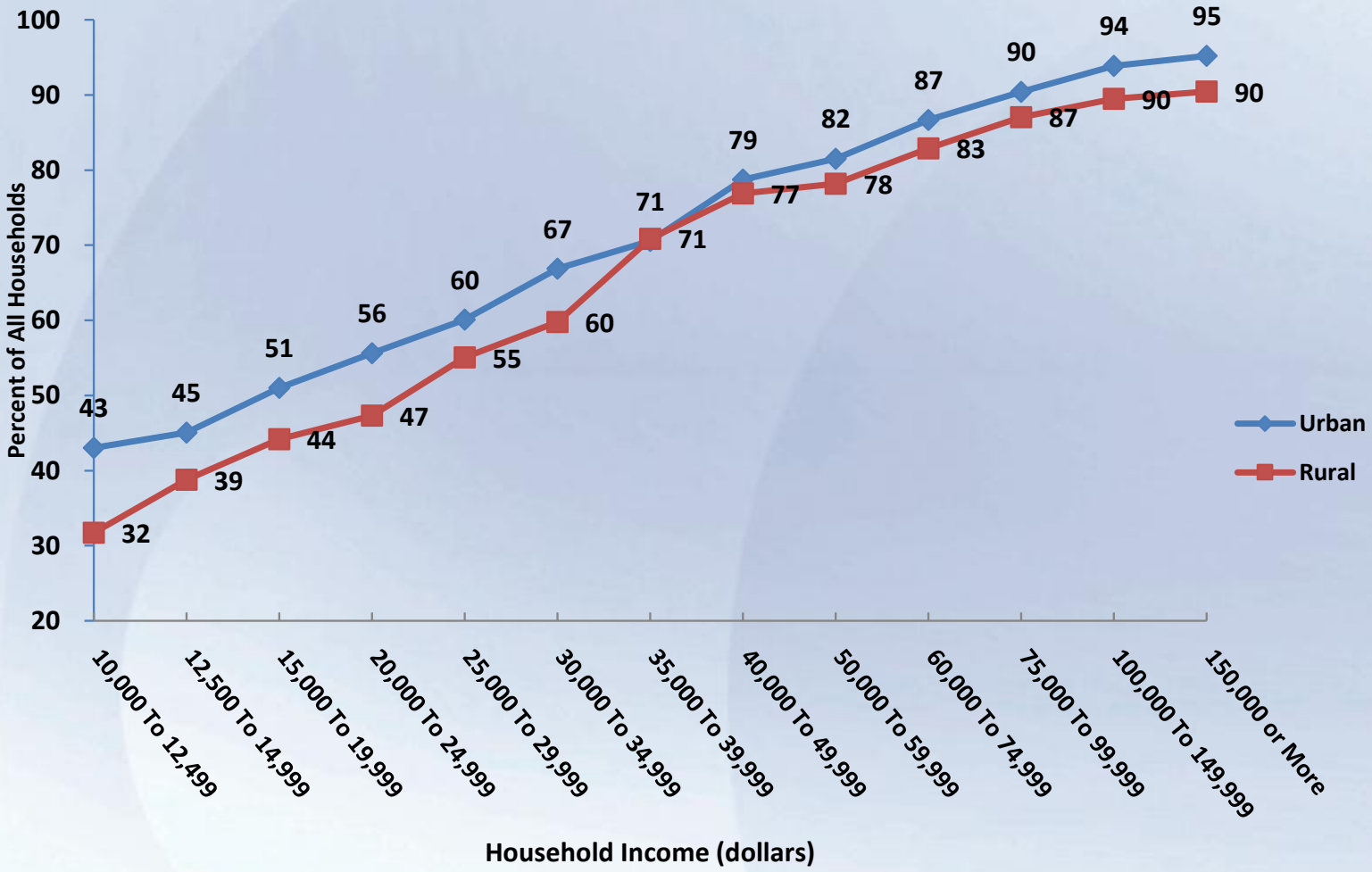
Fig. 4 Most Important Reason Households Gave for Not Having Internet Service, 2010



Source: ERS using Census data.

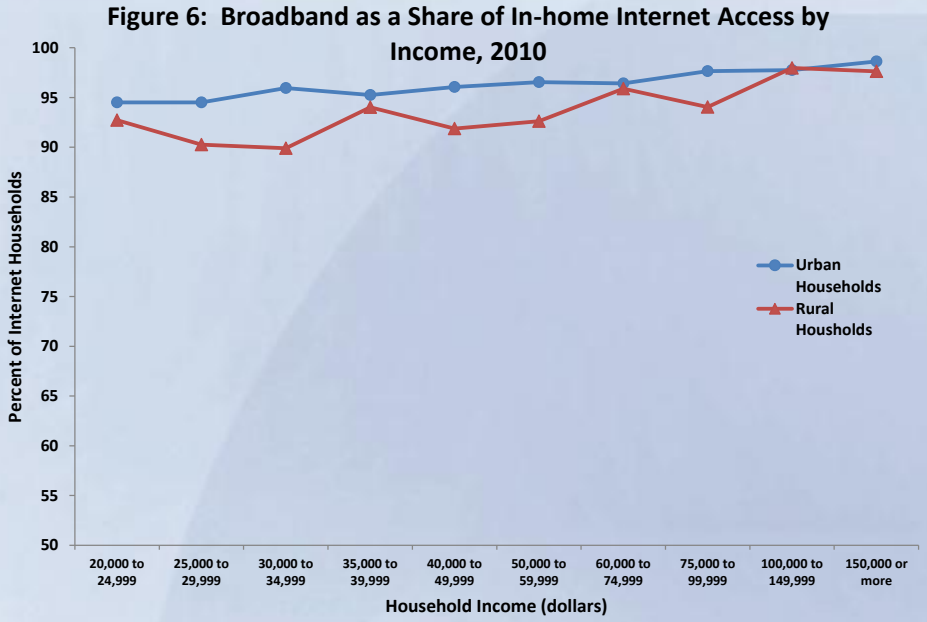
Rural and urban households similar across income levels

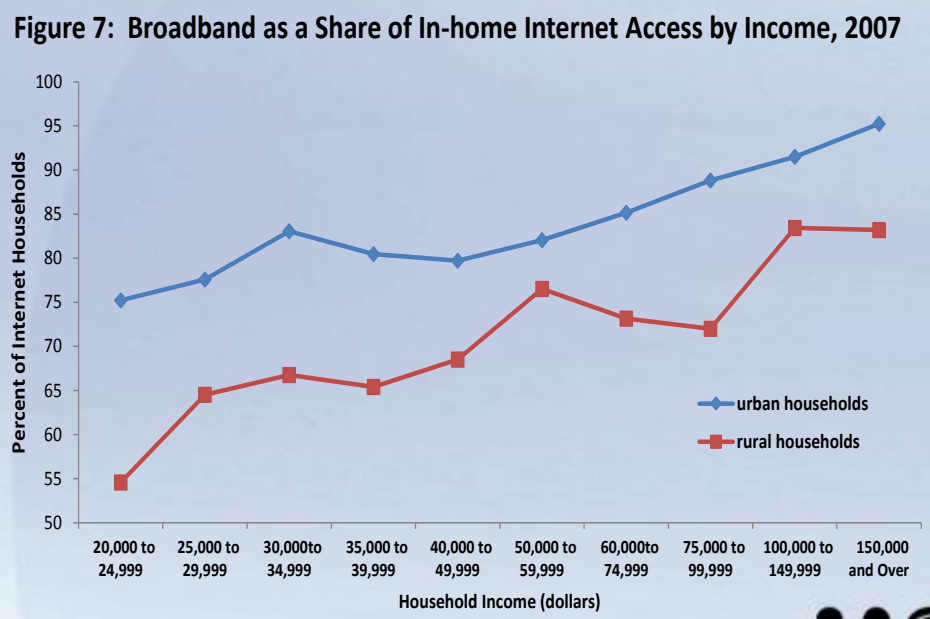
Figure 5: Rural and Urban Housesholds with In-home Internet Access Using any Technology, by Income, 2010



Source: ERS using Bureau of the Census CPS.

Rural broadband subscription shortfall at a given income level mostly due to availability





Source: ERS using Bureau of the Census data

Summary and further findings

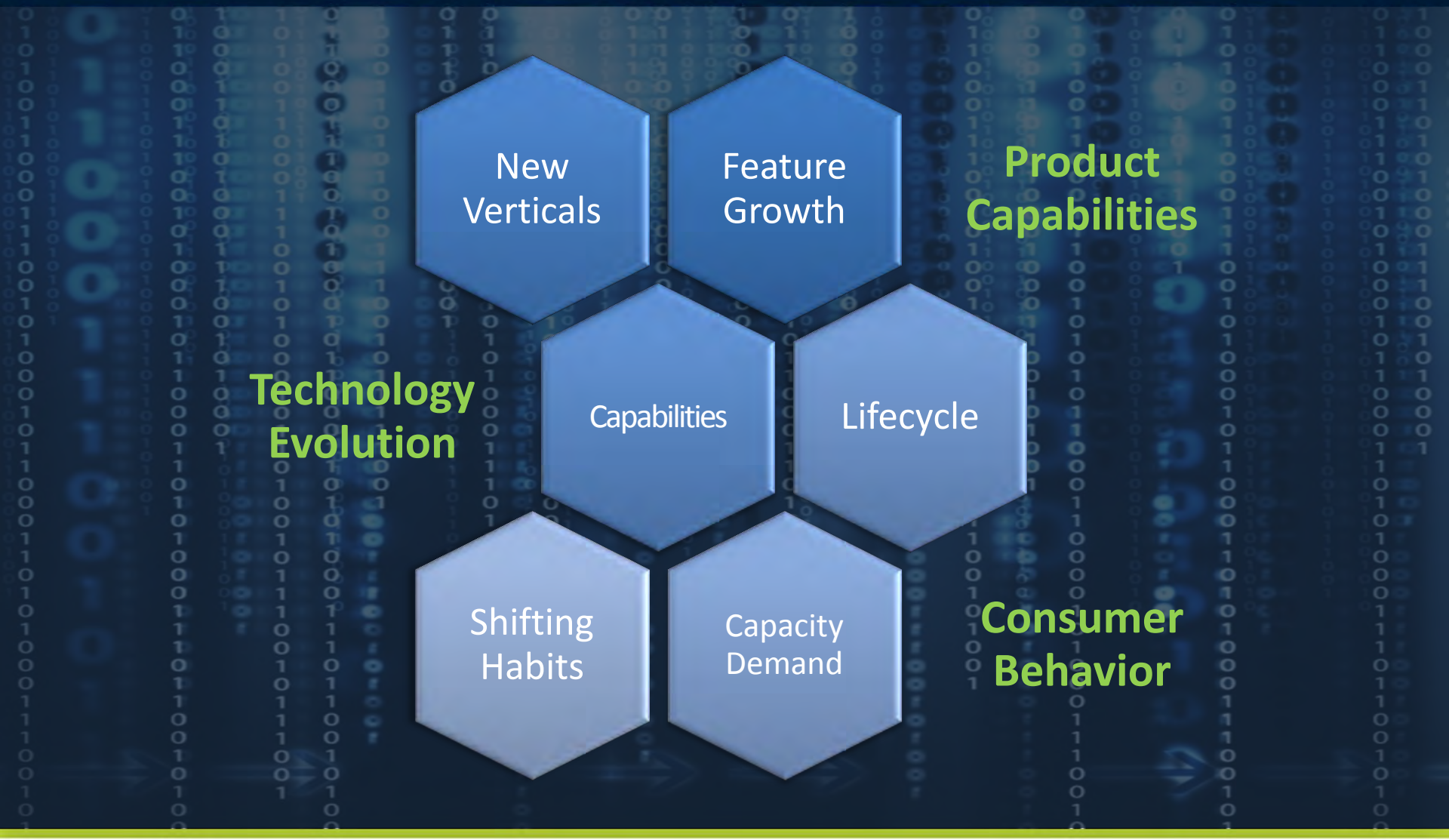
- Rapid broadband rollout, but not universal.
- Sharp differences in subscription rates across the country.
- Credence to the common hypothesis that people do choose to use broadband if given the option.
- The preponderance of DSL service for farms indicates both the mostly rural location of most farms as well as Internet users finding satellite a less desirable option.

Technology Transitions Policy Task Force Workshop

John Civiletto

March 18th, 2013

Drivers for Network Architecture



Voice Services Planning

Business Needs	• Support business goals & product richness (new features, convergence)
Common Architecture	• Rationalize existing technologies driving to a company-wide common architecture aligned on industry standards • Supporting needs in both consumer and enterprise segments
Operational Excellence	• Enable simplified management, routing, and interconnect • Optimize financial and operational investments
Reuse	• Leverage/integrate existing components that are aligned

Video Services Planning

Content	• Expanding ability to aggregate linear and off-line content sources
Experience	• Consistent and compelling user experiences • Highly personalized with search and recommendations • Enable consumer devices with new navigation capabilities
Portability	• In-home and mobile consumption of content • Enabling Consumer Electronics devices over DLNA Premium Video services
Convergence	• Scalable and agile – built on reusable components • Seamless delivery over legacy or broadband

Network Technology Planning

Centralized Services	• Architecting the network to enable delivery of consumer services from key strategic locations
Transport Growth	• Converged IP infrastructure with focus on enabling very dense high capacity links (100Gb/s launched) in backbone and metro architectures
Access Technologies	• Continued evolution of DOCSIS technologies • Extending existing HFC architecture
In Home Networks	• Transparent connectivity for the widest range of devices • Enhanced tools to help consumers manage quality of experience

Thank You

The 1000X mobile capacity challenge

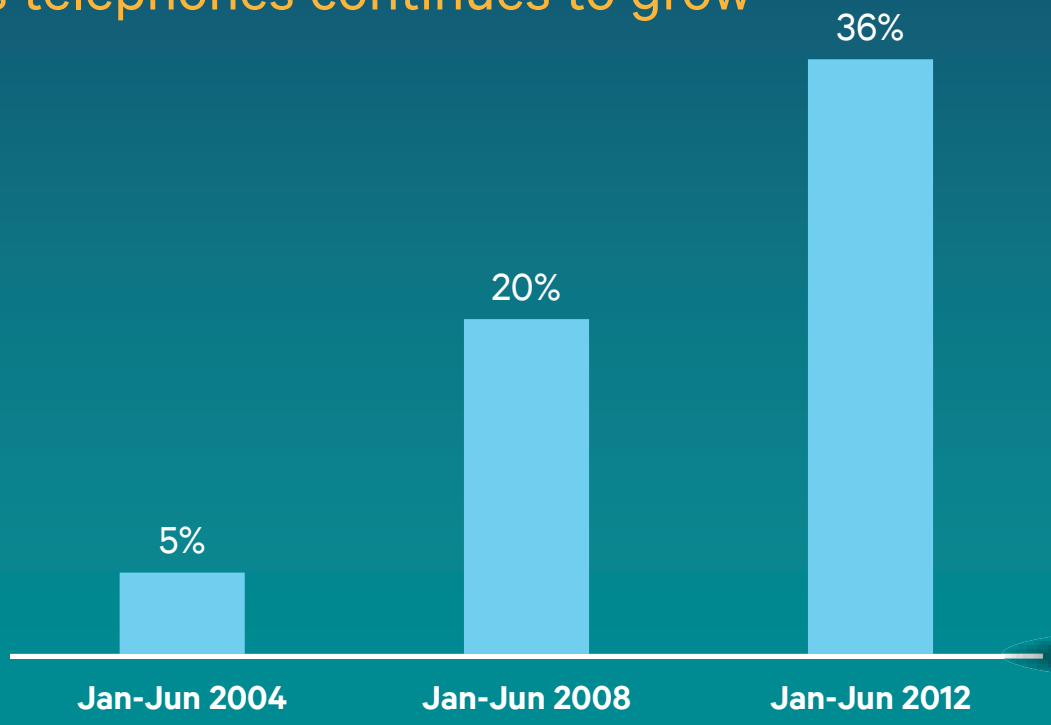
QUALCOMM®

Matt Grob, Chief Technology Officer

March 18, 2013

Wireless-only is becoming the norm

Percentage of American homes with only wireless telephones continues to grow



Source: CDC/NCHS, National Health Interview Survey

Mobile data traffic growth

Global data traffic growth

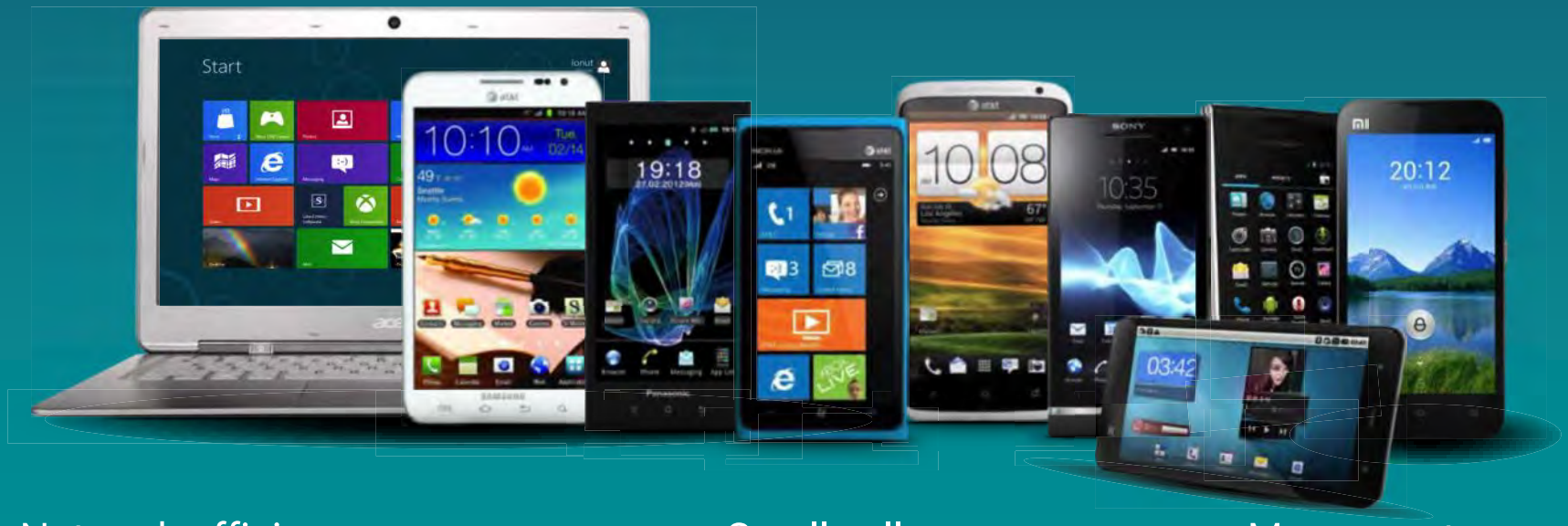
~2x

from 2010–2011*

Preparing for

1000x

data traffic growth



Network efficiency

Small cells

More spectrum

Source: Cisco, Feb '11

The future of wireless networks

Extreme densification with small cells

3G/4G

Continuous 3G/4G evolution

LTE broadcast

Device-to-device communications

Accessing spectrum resources

Licensed spectrum auctions

Authorized shared access

Unlicensed

Small cells everywhere

Low cost, small size and ease of deployment

Tests show indoor small cells providing coverage outside

Signal strength [dBm]

-55 to -65*

-65 to -75

-75 to -85

-85 to -95

-95 to -105

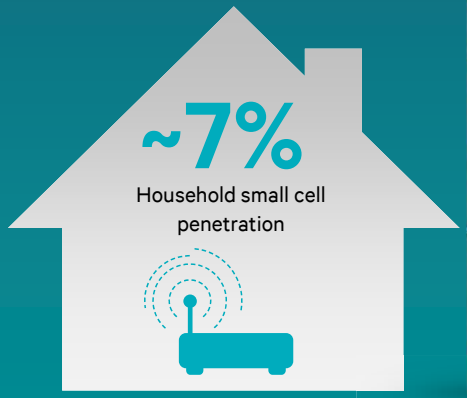
-105 to -115

Excellent performance

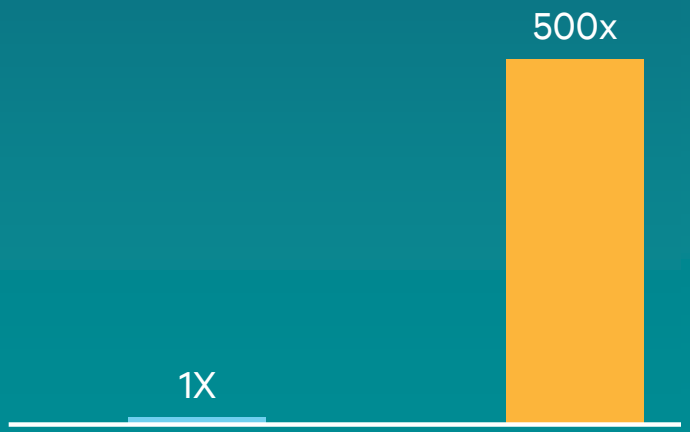
Very good performance

~700kbps

Acceptable performance



Source: Qualcomm Research; shows actual measured received pilot strength for small cell deployment; -115dBm results in ~700kpbs for Rel-7 5MHz in thermal noise limited case; points with RSCP less than -115dBm is not shown on the plots



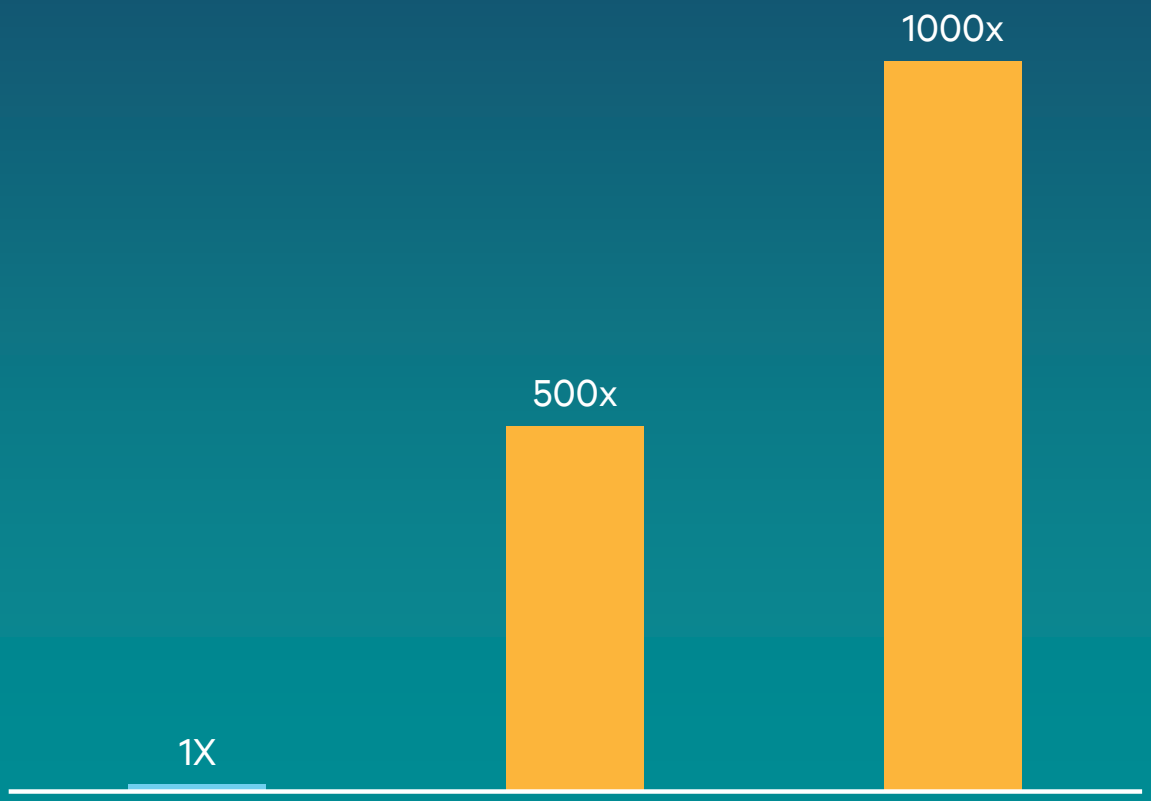
9%

Small cells

10x

Additional spectrum

Source: Qualcomm research



20%

Small cells

10x

Additional spectrum

Source: Qualcomm research

Thank you

Follow us on:

For more information on Qualcomm, visit us at:
www.qualcomm.com & www.qualcomm.com/blog

Frontier Communications: Building the Broadband Future in Rural America

Presented By: Michael Golob, Senior Vice President, Engineering & Technology

Date: March 18, 2013

Company Overview

Customers: 3.17 million

States: 27

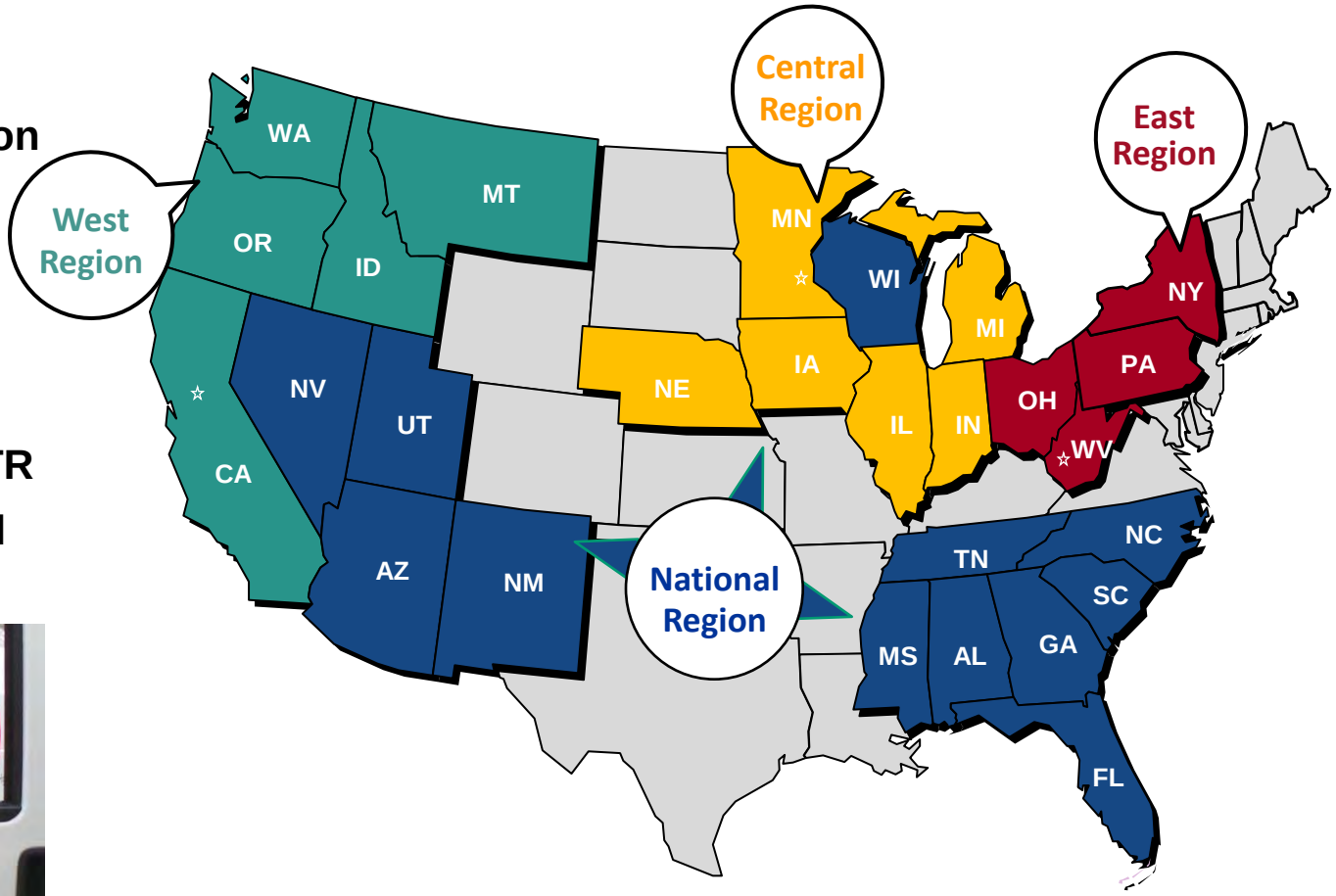
Regions: 4

Employees: 14,700

100% US-based

S&P 500/NASDAQ: FTR

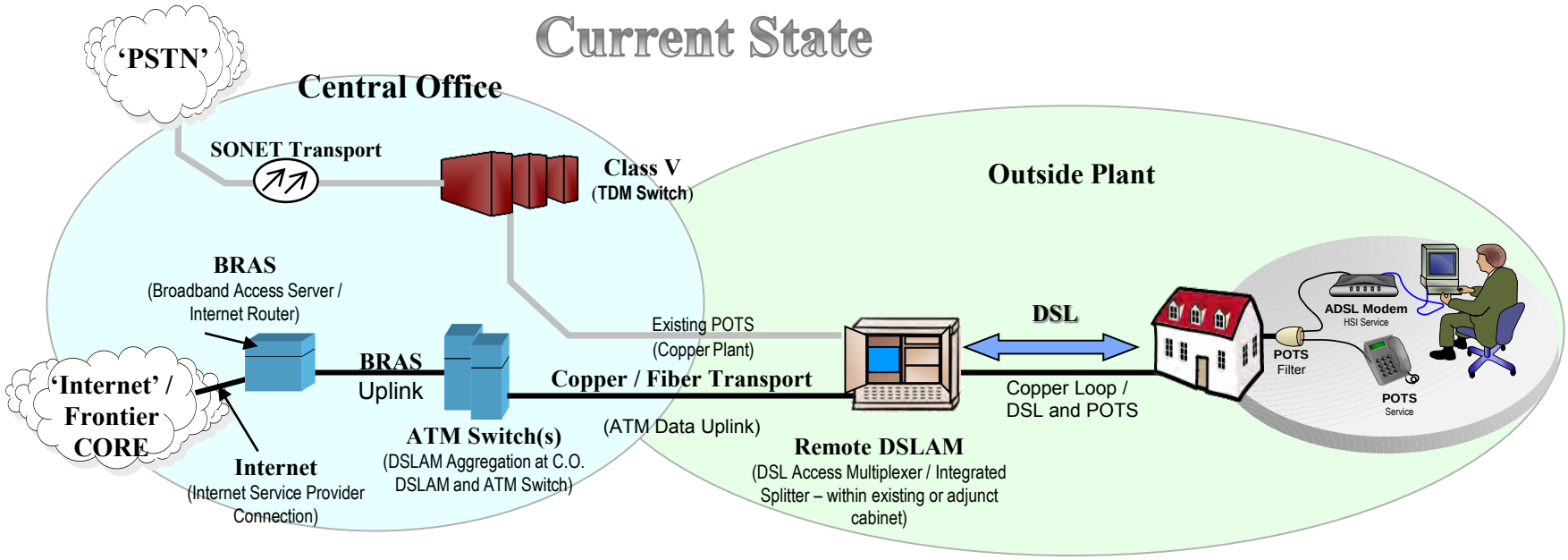
Profile: primarily rural



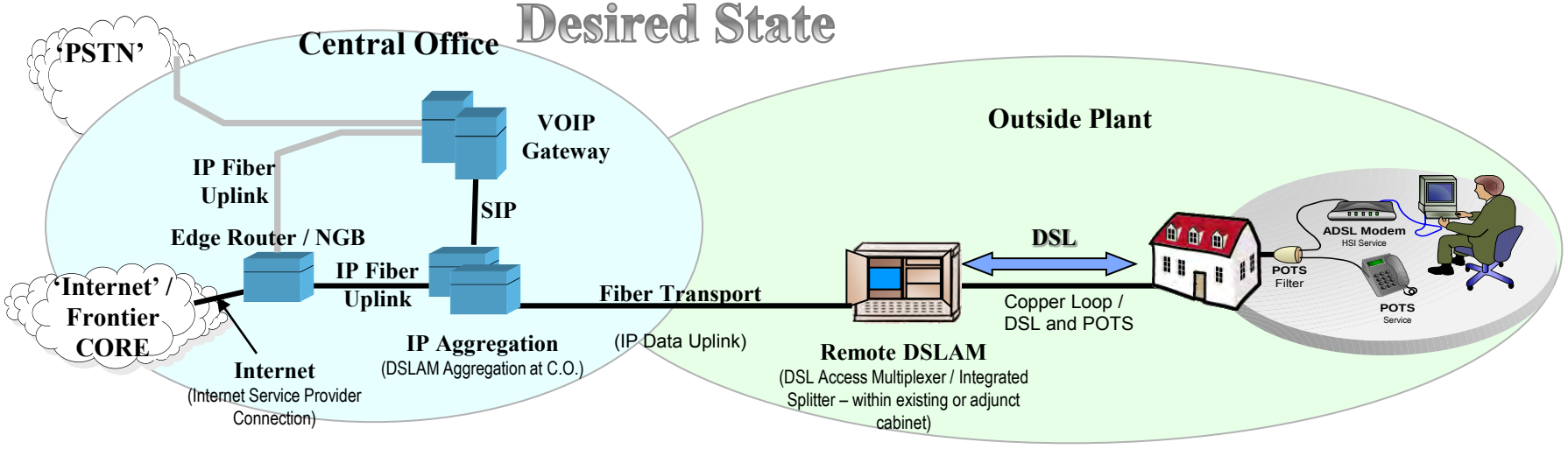
Frontier Network Modernization Plan

- Build a converged network capable of **delivering all services**
  - Data, voice, and video can transit the same pipe with **appropriate priorities** being applied/provisioned
  - Goal is to **maximize the bandwidth utilization** of the network and provide a quality experience for the customer
  - We are investing in a **standard network architecture** capable **of rapidly deploying new products and services** across Frontier's footprint
- Continue to deploy fiber deeper into the network – Fiber to the DSLAM or fiber to the curb
- A Total Cost of Ownership (TCO) model drives network decisions
- Must proactively manage network traffic
- Leverage existing plant and equipment to optimize return-on-investment– retain copper in the last mile in rural markets

Current State



Desired State



Impacts of Maintaining Dual IP/TDM Networks

- Dual Back Office Support
  - Provisioning Systems
  - Separate Equipment Management Systems
- Dual Staffing, Skills & Training
  - Engineering
  - NOCs
  - Provisioning
  - Field Techs
- Vendor Maintenance / Older Equipment is No Longer Supported
- Equipment Sparing

XO Network Evolution Overview

Randolph C. Nicklas

CTO & SVP Engineering

XO Communications

About XO Communications

- Leading nationwide provider of data and IP services
- Comprehensive portfolio of communications, managed network and IT infrastructure services
- Headquartered in Herndon, VA
- More than 3,100 employees
- Annual revenues of more than $1.5B

- Focus on business, large enterprise and wholesale customers
- Customers include more than 50% of the Fortune 500
- Leading brands across major industries
- Major cable, content, mobile wireless and domestic/global telecommunications companies

Our Customers

Large Enterprise

Abercrombie & Fitch, Boston Market, Cisco, Chipotle Mexican Grill, eBay, M&T Bank, Microsoft, Oracle, Thomson Reuters, United States Postal Service, Walgreens

Mid-Market

Blackboard, edisonlearning, Forman Mills, Kawasaki (Let the good times roll.), Larry H. Miller Group of Companies, SUB-ZERO, TRANSWESTERN, West Marine, UMassMemorial Medical Center

SMB

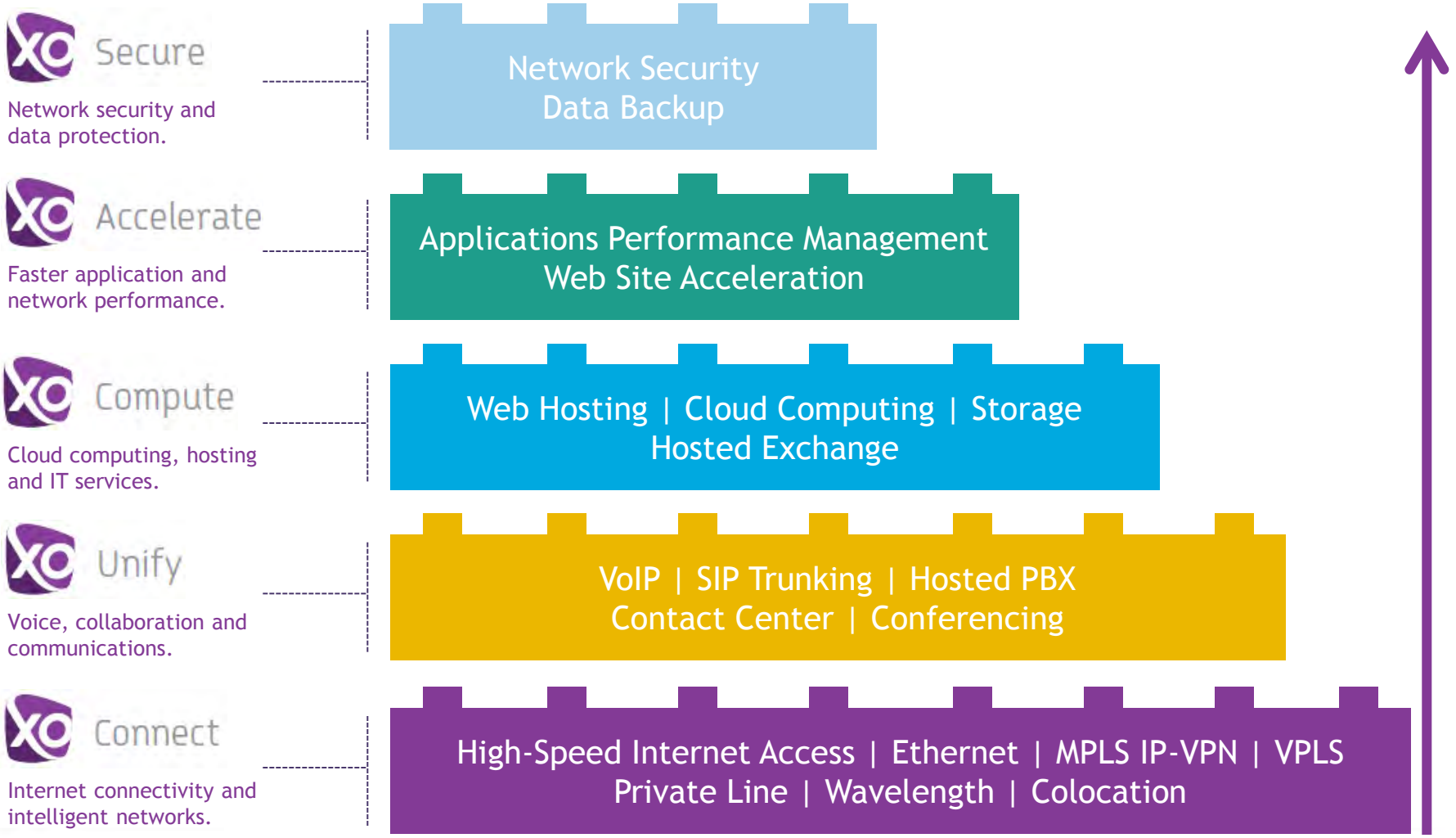
ColorTyme, Delta Resources, Inc., Monarch Title, Inc., The Voice of the Mattress Industry, ISPA, SendOutCards, URGO Hotels

Wholesale

BT, Cablevision, NTT, Cox Communications, Sprint, T-Mobile, Verizon Wireless, Time Warner Cable

Comprehensive Services Portfolio

The Right Services with Simple Pricing to Meet Your Communications, Networking and IT Infrastructure Needs



The XO Network

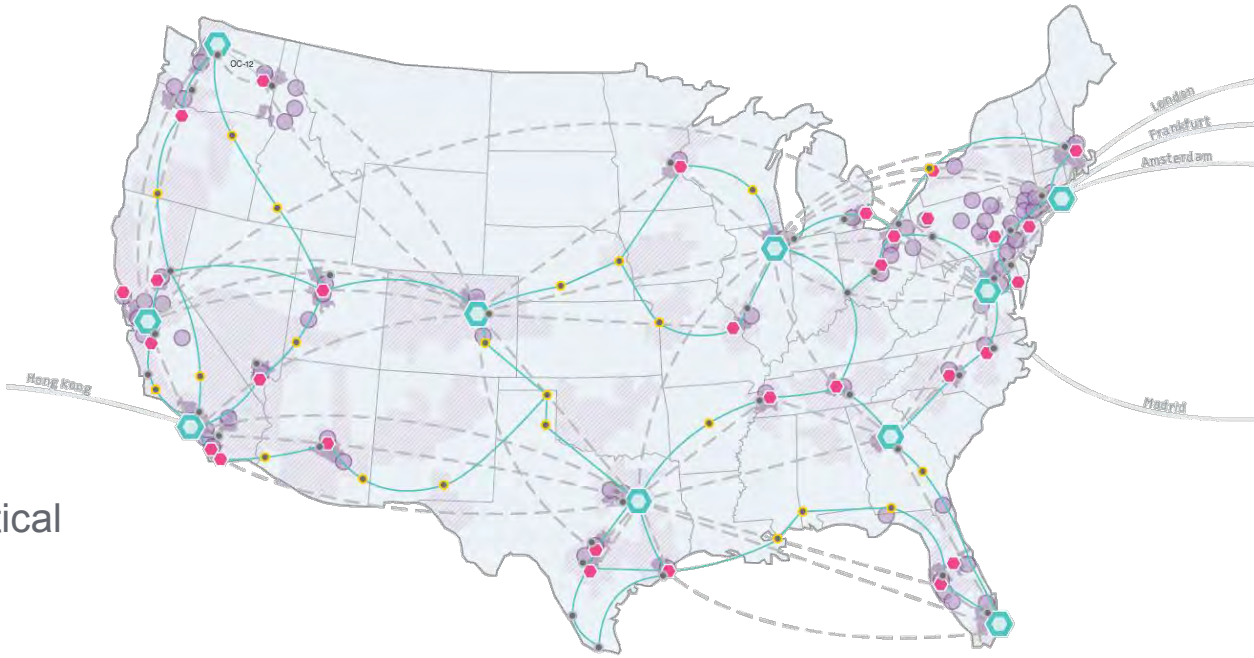
One of the Industry's Largest and Most Advanced IP Networks

Extensive Coverage

- 85 major metropolitan markets across United States
- Global service delivery to 50+ countries on 5 continents
- 3,300 on-net buildings
- Ethernet access to hundreds of thousands business locations

Robust Assets

- Tier 1 IP network
- Built using advanced IP and optical technology from Ciena, Cisco, Infinera and Juniper Networks
- 19,000 route mile inter-city miles
- ~ 1 million metro fiber miles
- 1,000+ colocation facilities
- Fixed wireless spectrum in 80 major metropolitan markets



Americas Region		European Region					Pacific Region	
Bermuda	Mexico	Austria	Estonia	Ireland	Malta	Slovenia	Australia	Philippines
Brazil	Panama	Bulgaria	Finland	Israel	Netherlands	Spain	China	Saipan
Canada	Peru	Belgium	France	Italy	Poland	Sweden	Guam	Singapore
Chile	Puerto Rico	Cyprus	Germany	Latvia	Portugal	Switzerland	Hong Kong	Taiwan
Colombia	US Virgin Islands	Czech Republic	Greece	Lithuania	Romania	United Kingdom	India	Thailand
Costa Rica	Venezuela	Denmark	Hungary	Luxembourg	Slovakia	Ukraine	Japan	

Network Snapshot: 2013 (Now)

- All new network investment and product development is exclusively on packet technologies
  - All telecommunications services can be delivered via IP
  - Ethernet is the best way to deliver IP services and is on its way to becoming the dominant access technologies (2 Mbps to 100 Gbps). 40% of new IP service turnups use Ethernet access (XO EoX or E-NNIs)
  - MPLS provides a great SP toolkit for network virtualization, fast protection switching and traffic engineering
- Harvesting legacy TDM and circuit-switched platforms (long legacy tail)
- Most new voice interconnect in form of VoIP; TDM trunking reduced
- Public IP traffic doubles every 12-15 months, driving successive overbuilds
- Private IP service foundational service for Business Customers
  - Variety of managed services layered onto this VPN service
- PHYs: Copper (access), Radio (access) Fiber (access & backbone)
  - 36% of US commercial business base passed served by fiber (VSG Mar 2013)
  - Continue to leverage unbundled Copper Pairs
  - 3G and 4G (2013) mobile networks for backup access
- New services and platform developments
  - 100G LH and metro DWDM
  - 100G P and PE router deployment; 100G IP transit ports
  - 2nd generation Cloud platform deployment (Private & Public IP access)

Network Snapshot: 2016 (Now + 3 years)

- IP/MPLS backbone growth continues, perhaps with slight de-acceleration
- Multiple IP networks on common MPLS + DWDM core
- SONET infrastructure near apogee
- Decommission of circuit-switched platforms continues…
- All new voice interconnect in form of VoIP; little or no TDM trunking
- Managed Services + Private/Public IP + Cloud Service bundles key
- PHYs: Copper (access), Radio (access) Fiber (access & backbone)
  - ~45% (estimate) of US commercial business base served by fiber
  - XO continues to expand its metro fiber networks….
  - Microwave backhaul of small(er) cell towers sees increasing use
  - Continue to leverage unbundled Copper Pairs
  - 3G and 4G mobile networks for backup IP access
  - 4G mobile networks for primary IP access
- New services and platform developments
  - 200 & 400G wavelengths in portions of LH and metro DWDM
  - 100G LH and metro DWDM commonplace in SP networks
  - Continued100G class P and PE router deployment
  - 100GE Private IP ports start to appear
  - Cloud platforms and services generating significant revenue

Network Snapshot: 2018 (Now + 5 years)

- IP/MPLS backbone growth continues, perhaps with a doubling rate of 24 months?
- SONET platforms capped (no new equipment deployments)
  - Ethernet dominant form of access
- Continued decommission of circuit-switched platform (driven by RE)
- PHYs: Copper (access), Radio (access) Fiber (access & backbone)
  - >50% (estimate) of US commercial business base served by fiber
  - XO fiber networks at or near peak
  - Microwave backhaul of small(er) cell towers commonplace
  - 4G mobile networks for primary and secondary IP access
  - Regulation of access networks?
- New services and platform developments
  - 1T wavelengths in portions of LH and metro DWDM
  - 100G LH and metro DWDM client services common for enterprise customers
  - P and PE router overbuilds continue, with 400GE trunk & transit ports
  - 100GE Private IP ports common place
  - Cloud platforms and OTT services and bundles dominate revenue

Network Snapshot: 2020 (Now + 7 years)

- IP/MPLS backbone capacities near steady-state
  - Everything is well connected!
  - At least for ~90-95% of the population…..
- SONET platforms being decommissioned
- ILEC wire centers winking out in top 100 MSAs
- XO circuit-switches eliminated
- PHYs: Copper (access), Radio (access) Fiber (access & backbone)
  - 55-65% (estimate) of US commercial business base served by fiber
  - Microwave and mobile RANs principle access alternatives to fiber
- New services and platform developments
  - New services??? All we know is they will be over a set of interconnected and sophisticated packet networks, with IP still the fundamental lingua franca
  - Emphasis on improvements in reliability and cost basis never-ending

FCC TECHNOLOGY TRANSITION TASK FORCE PANEL

MARCH 18, 2013

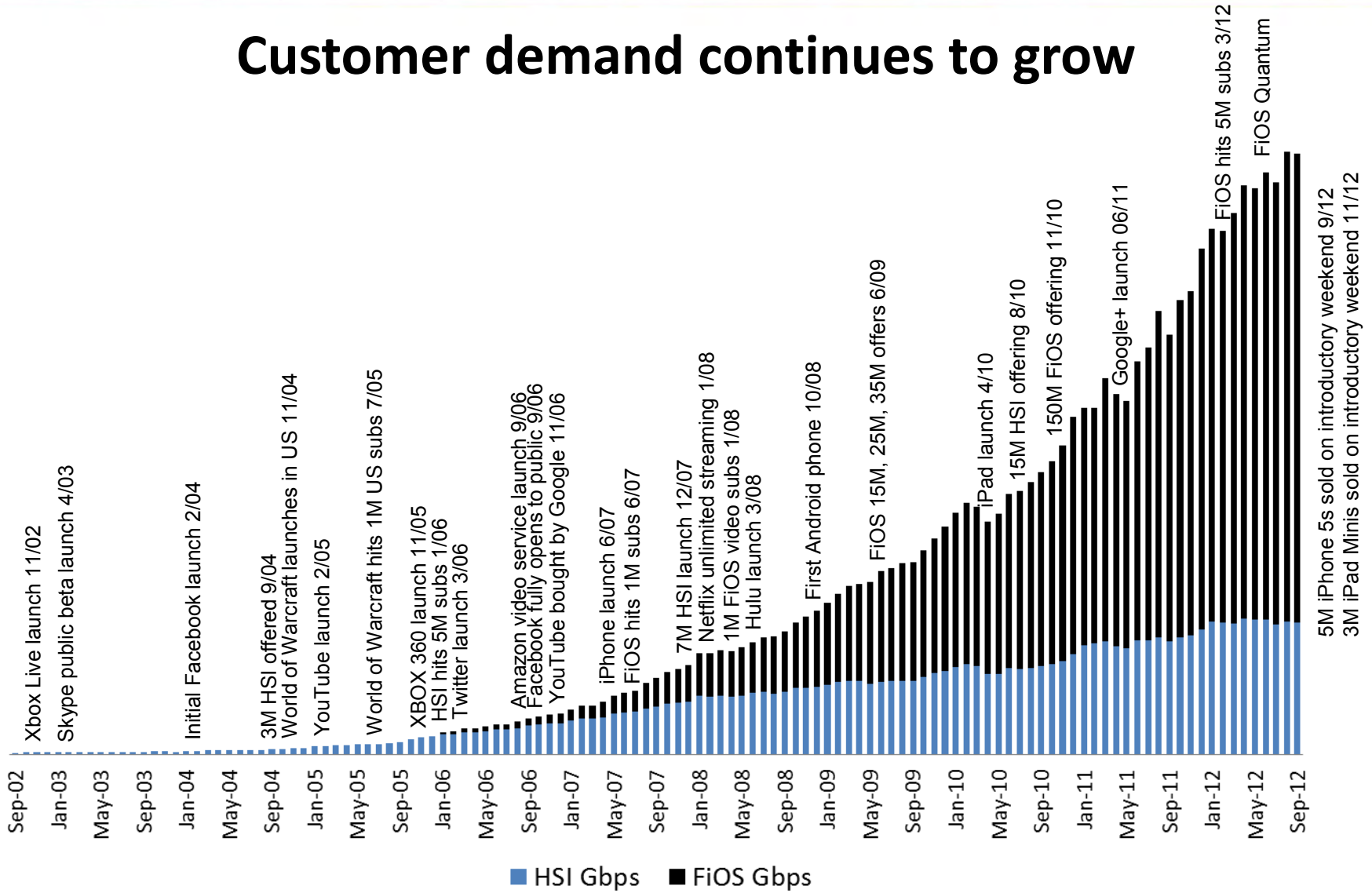
TOM MAGUIRE – SVP VERIZON

The Realities of Life in Telecom

- **Consumers have more choices than ever in how to communicate and now choose from a wide range of services, devices and networks.**
  - Large numbers of customers have already moved to cable or telco's next generation networks for their communication needs.
  - With 105% wireless penetration it is clear that communications is no longer limited to talking
  - Cord Cutters now, "Cord Nevers" on the horizon
- **The traditional copper network is limited in its ability to satisfy customers' growing demands**
  - Bandwidth capacity and speed is the future
- **The traditional copper network is aging and has inherent limitations despite our infrastructure improvement programs**
  - Metal + water + oxygen = service disruptions

Bandwidth Utilization

Customer demand continues to grow



Why Network Evolution?

Uses all the platforms available to us to best serve our customers

1. **Leverage our existing network investments to:**
   - Improve reliability
   - Deliver better service
   - Transition off manufacturer discontinued equipment
2. **Move copper customers to alternate technology for the same or better price**
   - Fiber
   - Wireless