

CALSpeed - California's Mobile Broadband Assessment

Fall 2014

(Spring 2014 measurement data)

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Novarum, Inc.
November 2014

Why Should We Care?

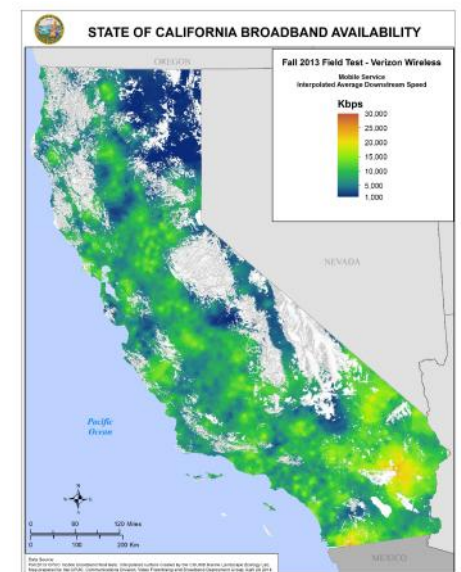
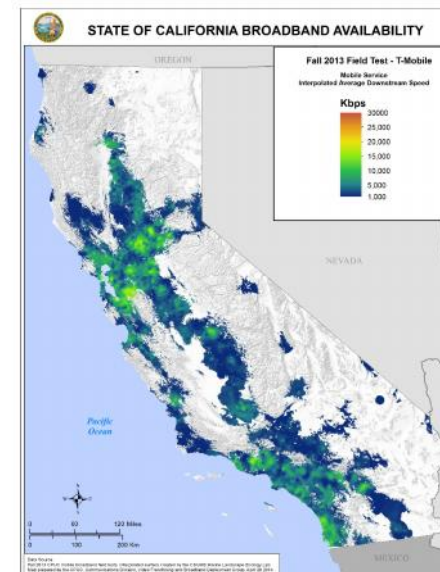
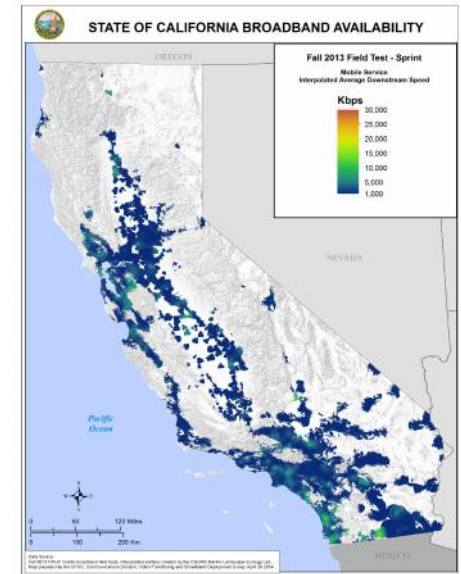
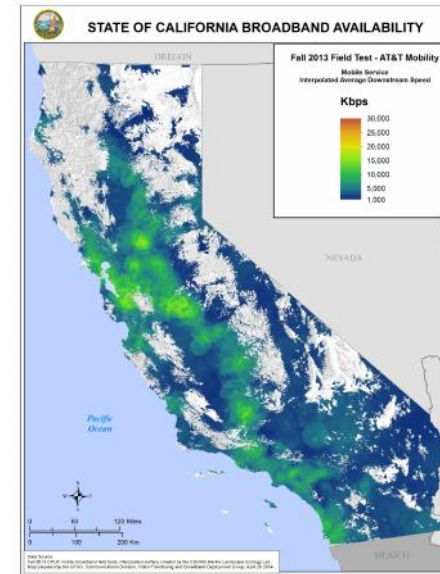
- Mobile broadband quickly becoming the de facto mission critical Internet access
- Service providers have provided inadequate information about coverage, performance and quality
- Identify and document the Mobile Digital Divide
 - Rural and tribal with half the service of urban
 - Allocate State resources effectively
- Public Safety
 - Mobile critical to first responders and citizens in emergency management
 - Is there adequate service for Highway Patrol video streaming of accidents?
 - What is the quality of service in high fire risk areas?
 - Is mobile service adequate for each school's public safety needs?
 - Assess FirstNet coverage, performance and quality of service
- Smart resource management
 - Water management for irrigation
 - Energy
- CALSpeed provides answers to these questions

Some Questions We Wanted Data For

- What is the quality of mobile broadband Internet throughout California?
 - Urban, Rural, Tribal
 - Including where there are no crowds
- What is the quality of the end-to-end mobile broadband user experience?
 - Radio network and backbone to servers throughout the Internet
- How is the quality of mobile broadband changing over time?
- How does the quality of mobile broadband correlate to other demographic factors?
 - Economic, geographic, political
- How ready is mobile broadband to replace wire?
- What can we determine about the quality of middle mile?

Uniquely Competent Measurement

- Open Source
 - Based on industry standard open source tools
- End-to-end User Experience
 - Both near and far servers
 - Upstream and downstream TCP throughput
 - Latency
 - Packet loss
 - Jitter
 - MOS for VoIP
- Not Just for Crowds
 - Explicit sampling in 1,986 locations throughout California
 - Urban, rural, tribal
 - Multiple devices (smartphone, laptop/tablet)
 - Repeated at the same location with same measurement at periodic intervals (~10,000,000 measurements to date)
 - Complemented by crowd sourced data
- Just the facts
 - No filtering of measurements
- Maps for decision makers
 - Advanced geostatistical techniques to translate raw measurements into geographic information



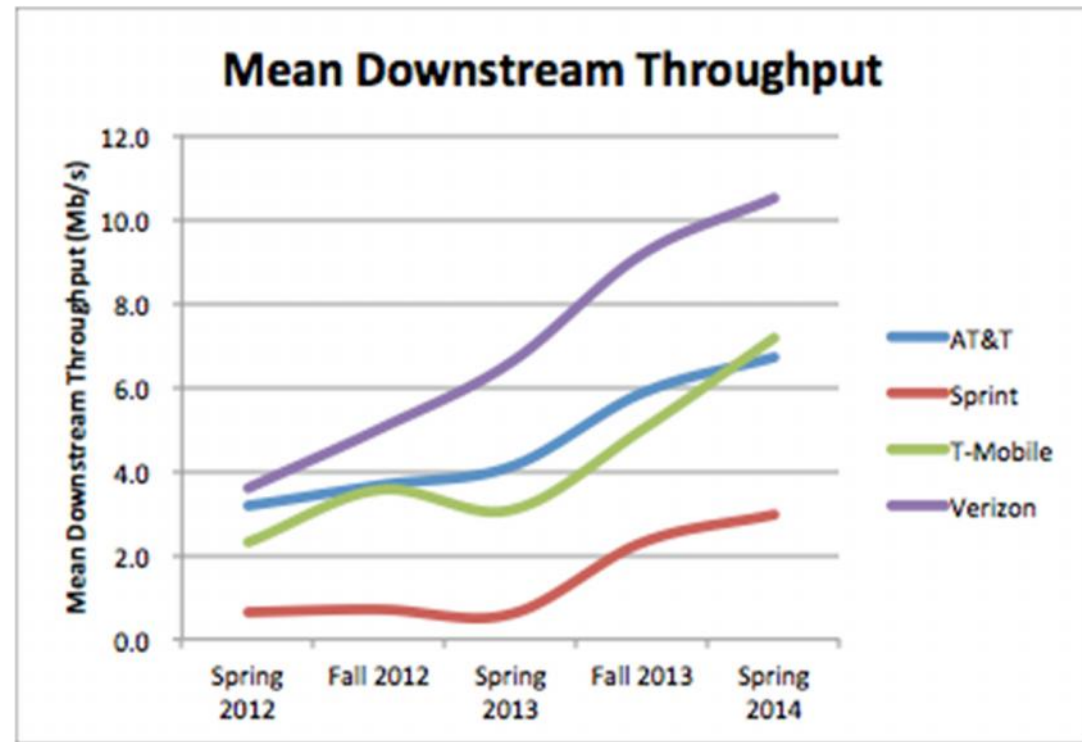
Six Key Themes

Two+ Years of Data
Spring 2012 - Spring 2014

- Mobile broadband continues to get much better VERY quickly (on average)
- Wide variation in mobile broadband performance across California
- Not all carriers are equal
- Mobile broadband service is not just wireless access
- Real and growing mobile digital divide
- Bulk of California's mobile network is still not yet VoIP ready
- Measured service substantially less than advertised

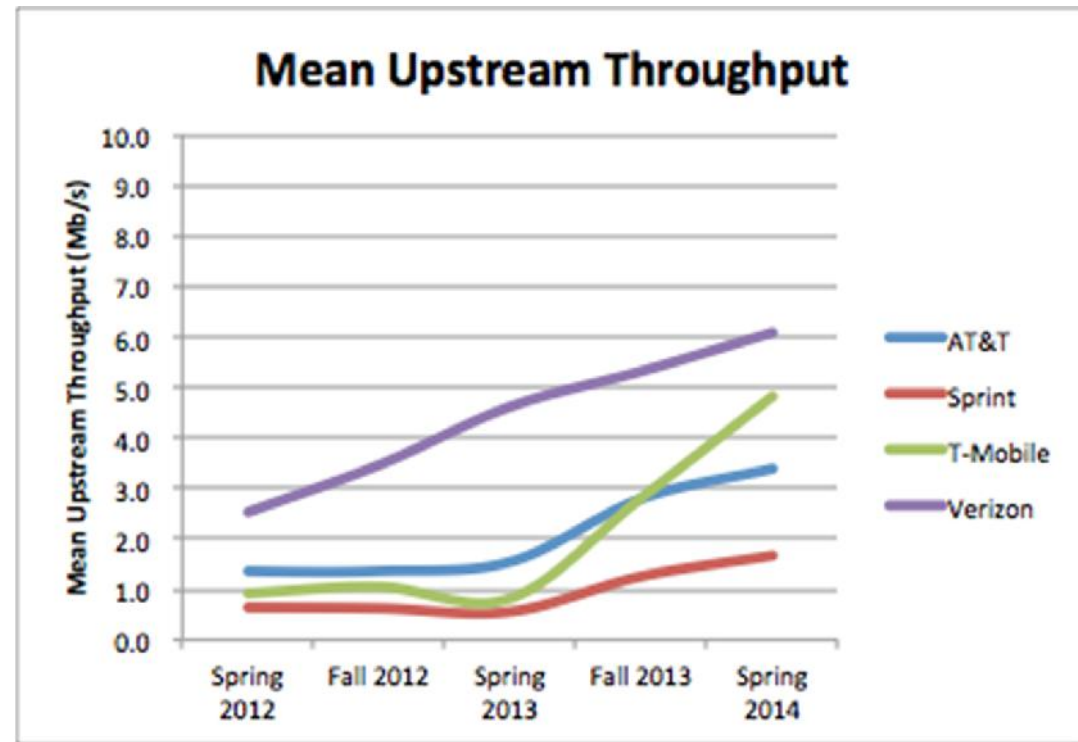
Mobile Broadband Improving Quickly (On Average)

- Best carrier (Verizon) triples mean downstream throughput



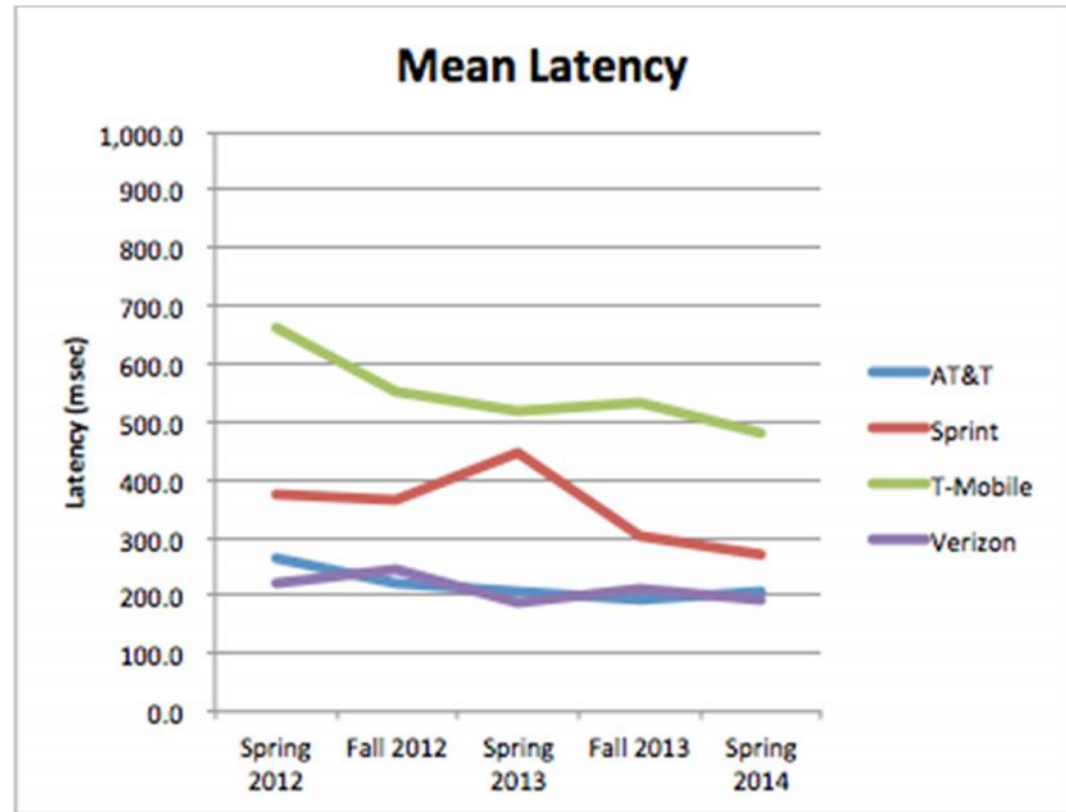
Mobile Broadband Improving Quickly (On Average)

- Best carrier (Verizon) triples mean downstream throughput
- Best carrier (Verizon) doubles mean upstream throughput



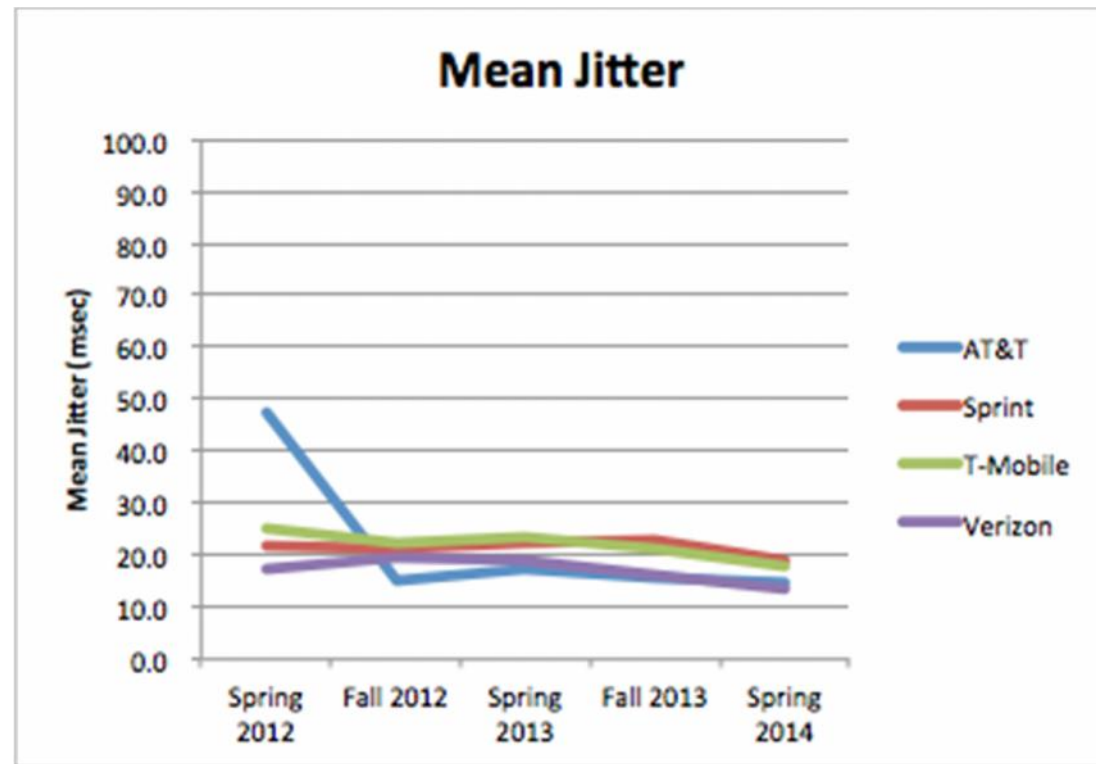
Mobile Broadband Improving Quickly (On Average)

- Best carrier (Verizon) triples mean downstream throughput
- Best carrier (Verizon) doubles mean upstream throughput
- Latency continues to improve



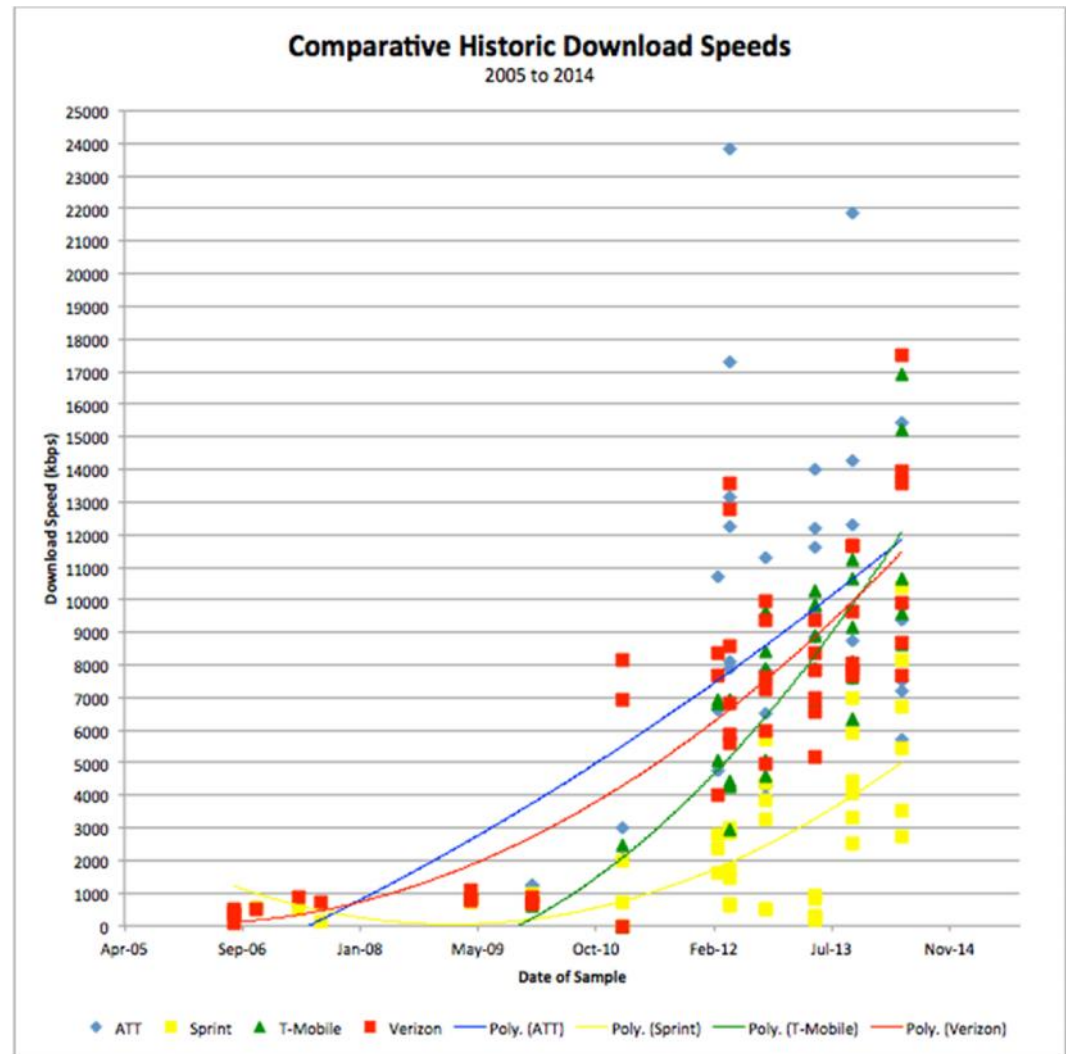
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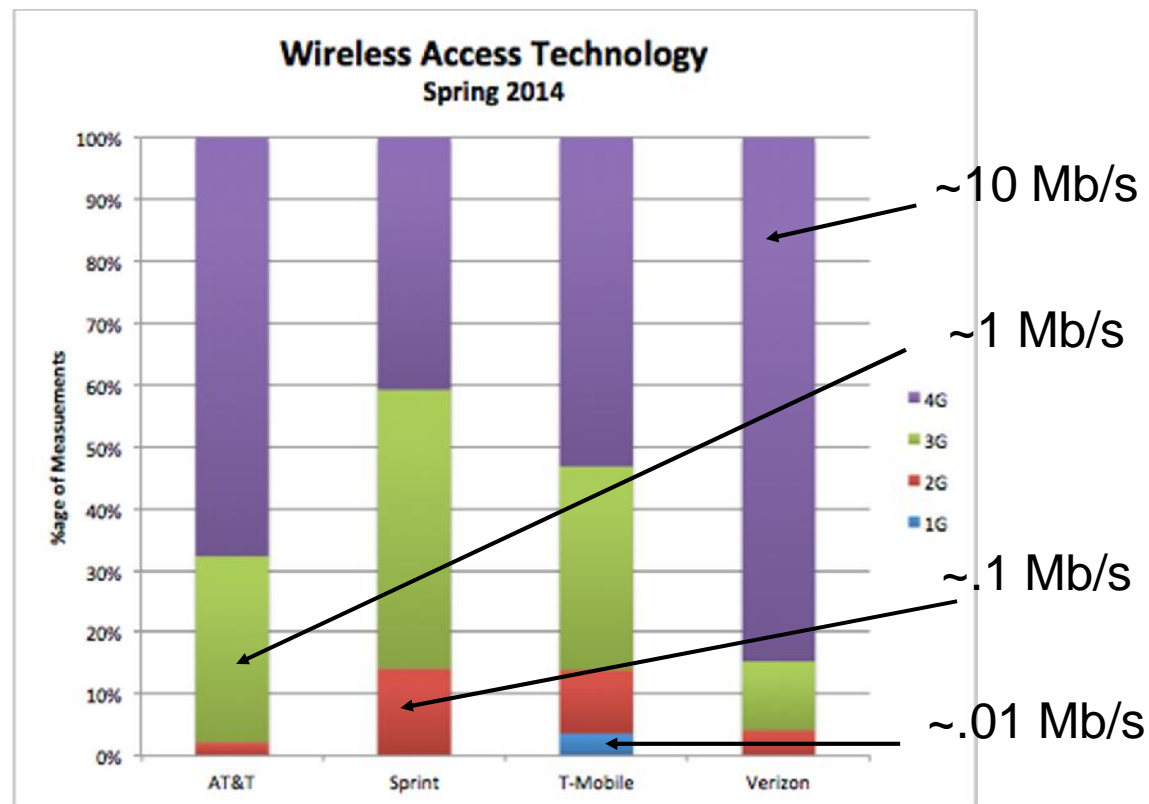
Mobile Broadband Improving Quickly (On Average)

- Best carrier (Verizon) triples mean downstream throughput
- Best carrier (Verizon) doubles mean upstream throughput
- Latency continues to improve
- Jitter continues to improve
- Historic growth trend in mobile performance



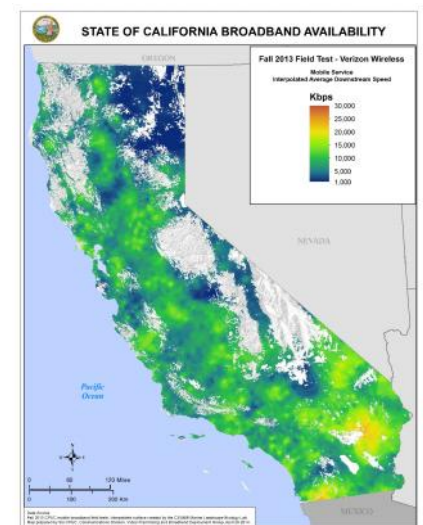
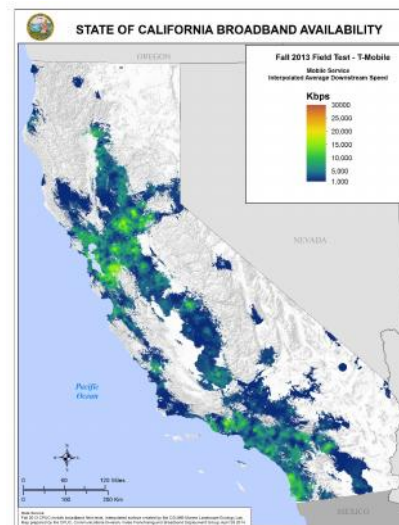
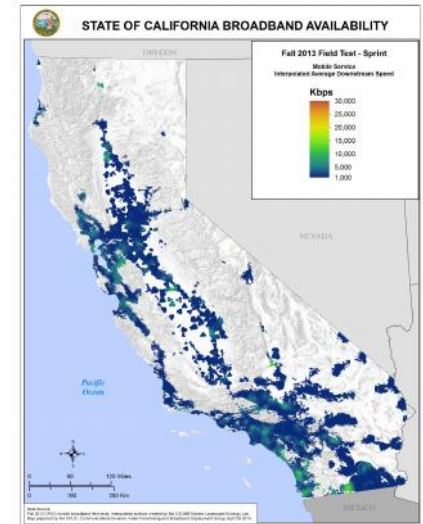
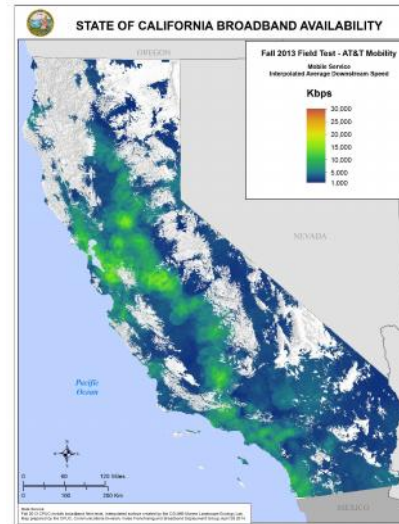
Mobile Broadband has Wide Variation

- Wireless Technology (1000x)
 - Choice of local wireless access technology



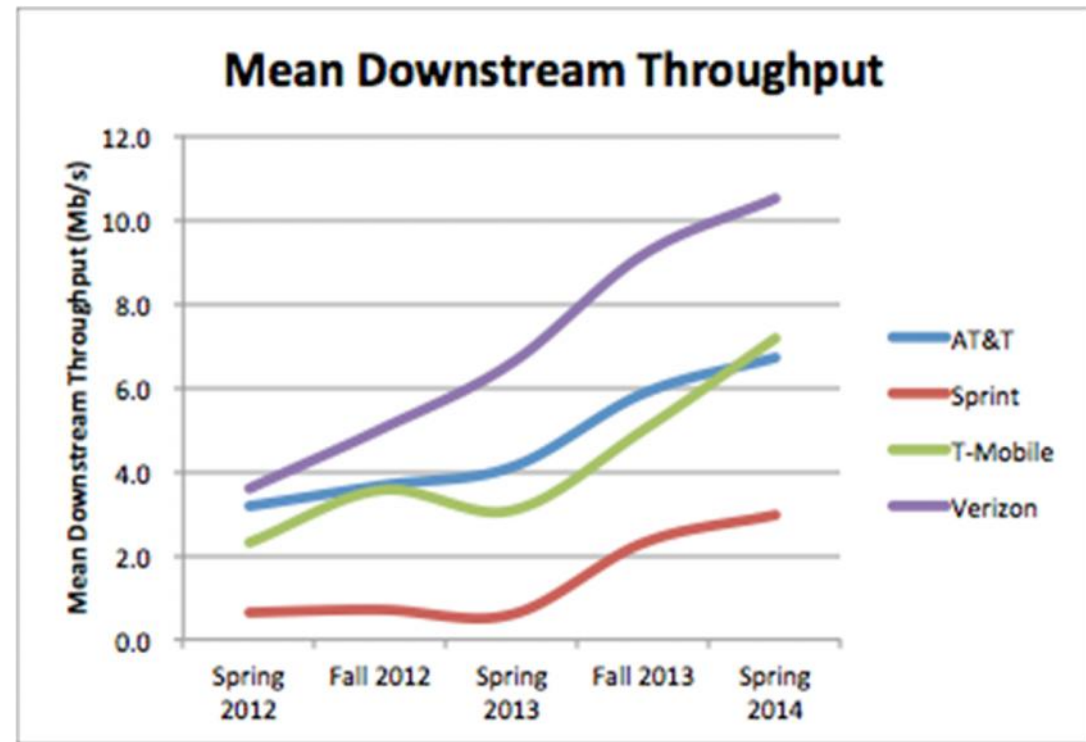
Mobile Broadband has Wide Variation

- Wireless Technology (1000x)
 - Choice of local wireless access technology
- User Location (30x)
 - Tower density and location
 - Choice of backbone peering policy



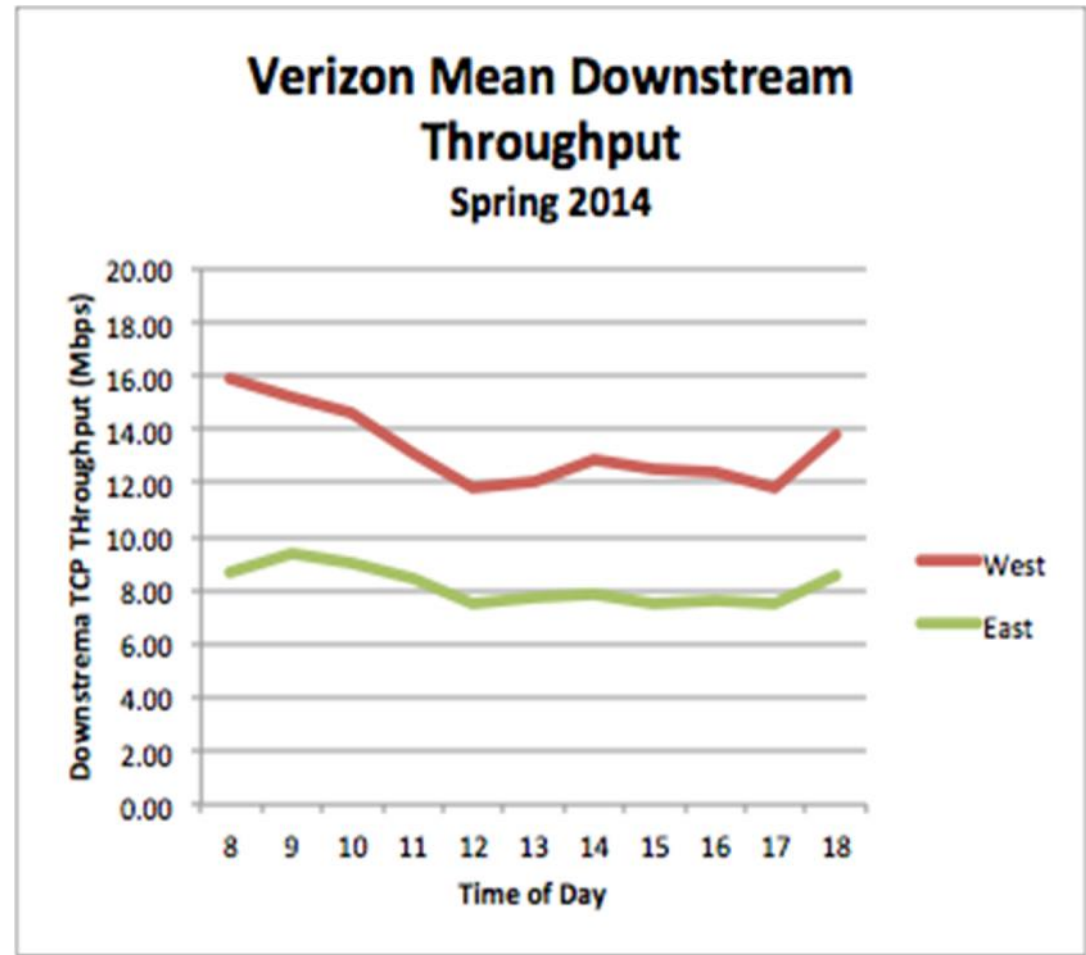
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- Carrier (5x)



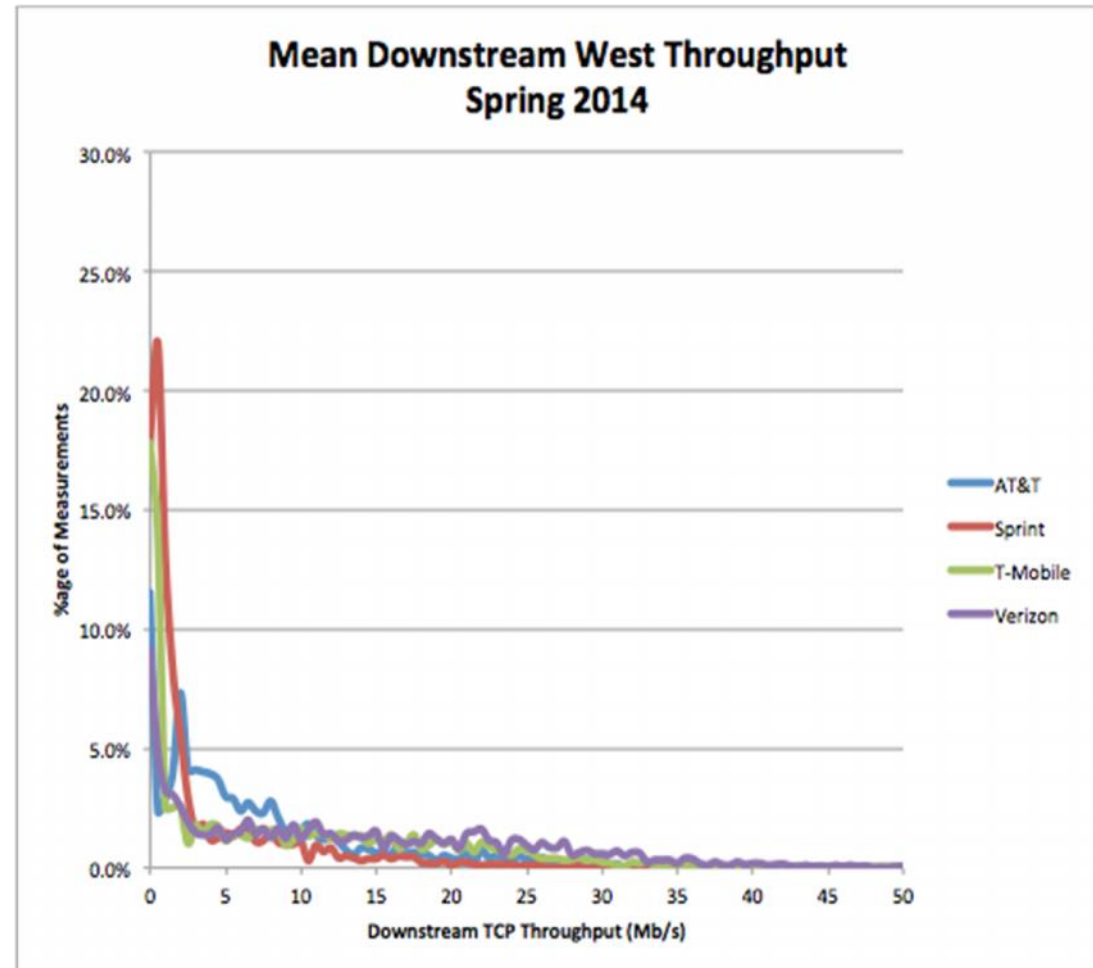
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- Carrier (5x)
- Location of Internet Service (2x)



Mobile Broadband has Wide Variation

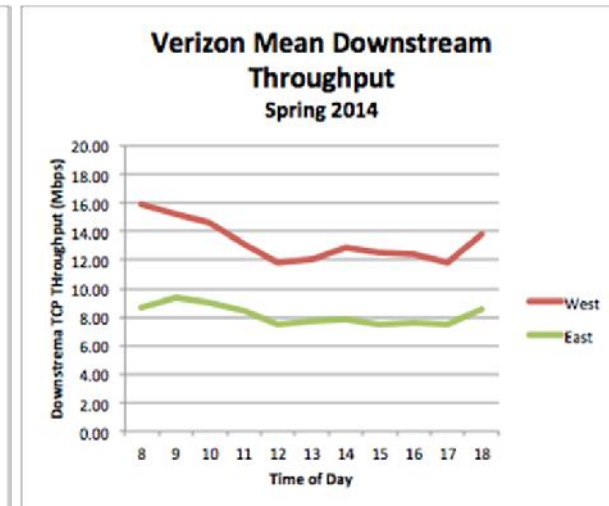
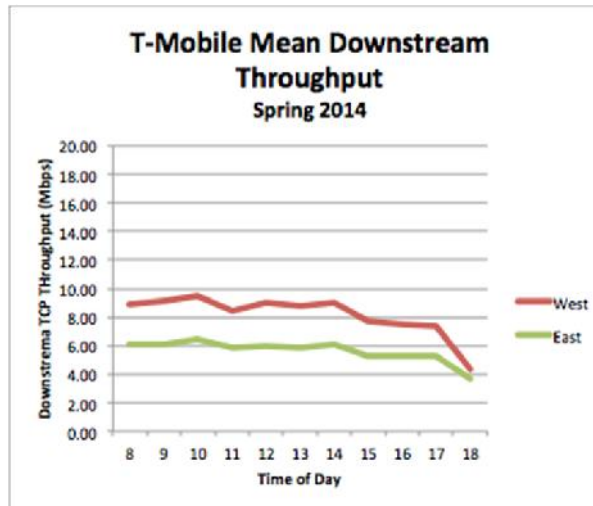
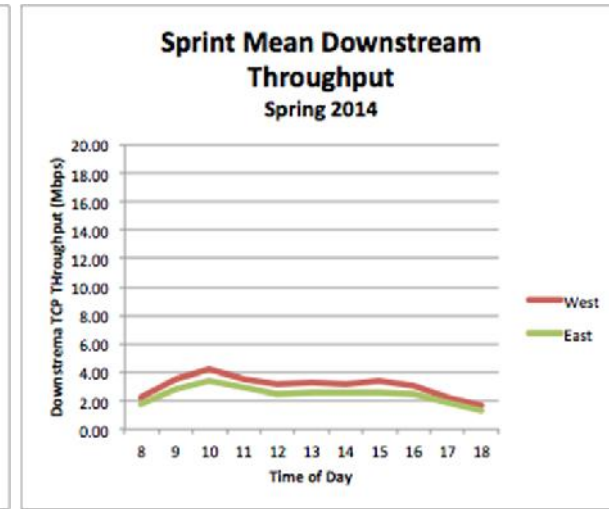
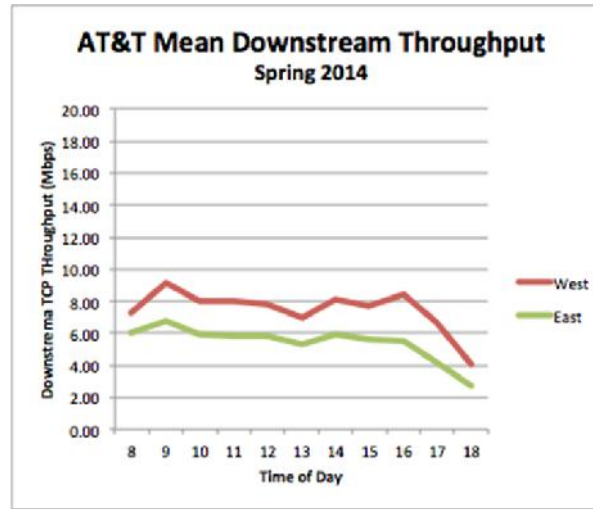
- Wireless Technology (1000x)
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- User Location (30x)
 - Tower density and location
 - Choice of backbone peering policy
- Carrier (5x)
- Location of Internet Service (2x)
- Huge variation as seen by user



Modest Variation

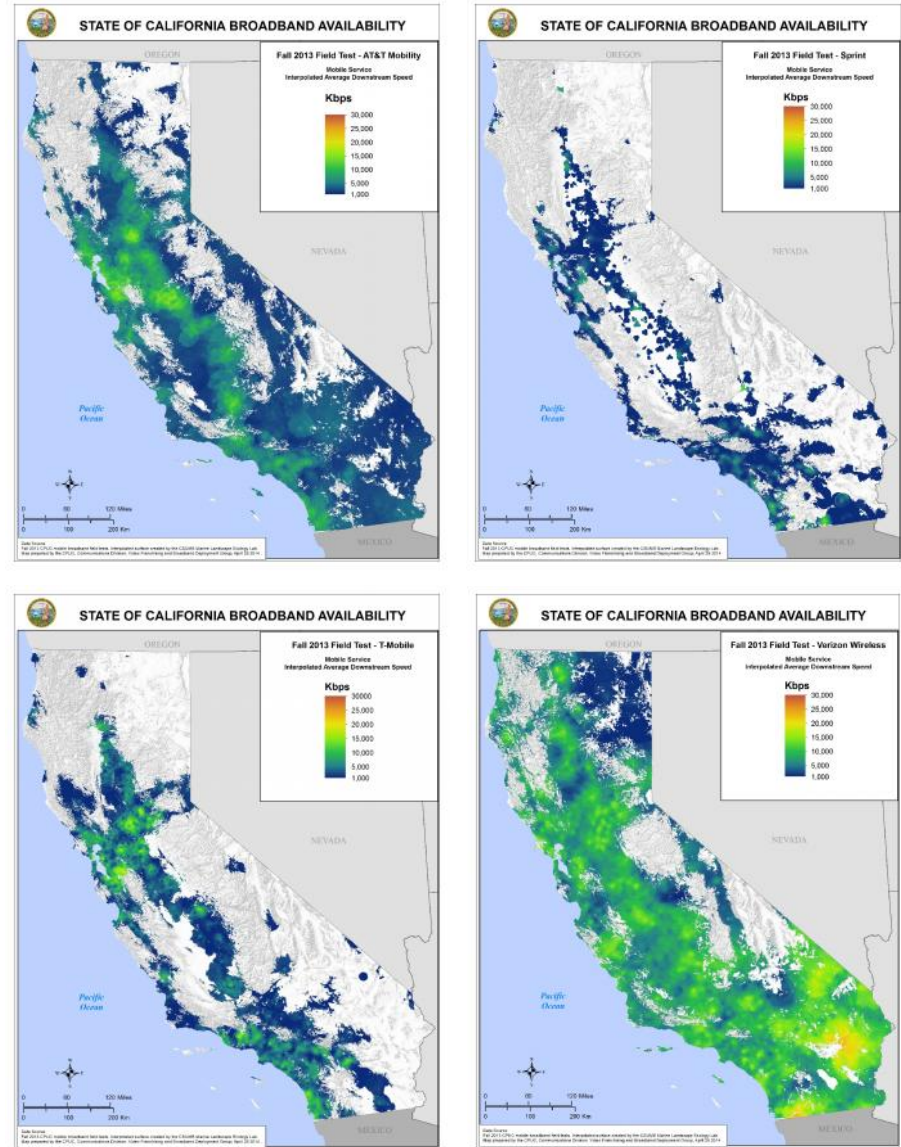
by Time of Day

- Modest variation by time of day (~.2x)
 - Only measured daylight hours
 - Similar pattern for upstream throughput
- Less important than
 - Location of user
 - Carrier
 - Wireless technology
 - Location of service
 - User device choice



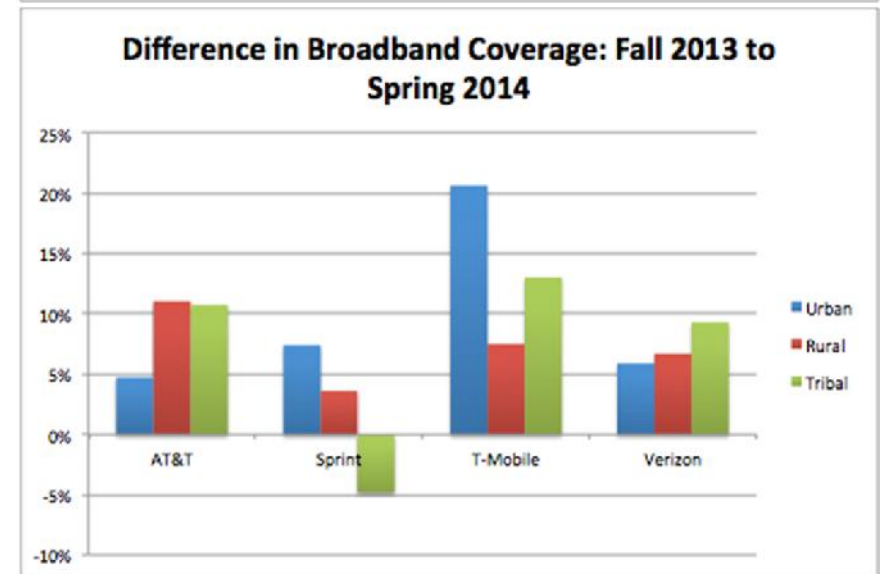
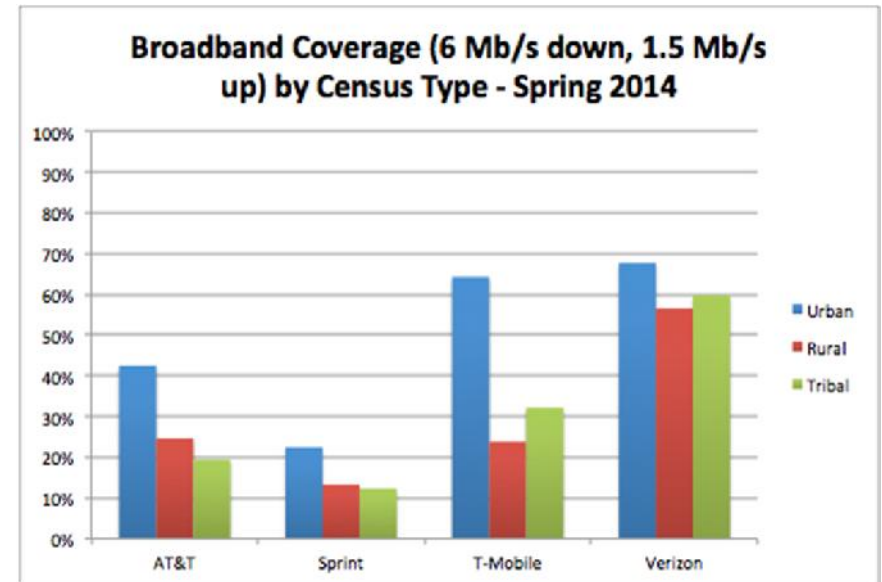
Not All Carriers Are Equal

- Wide variation in coverage



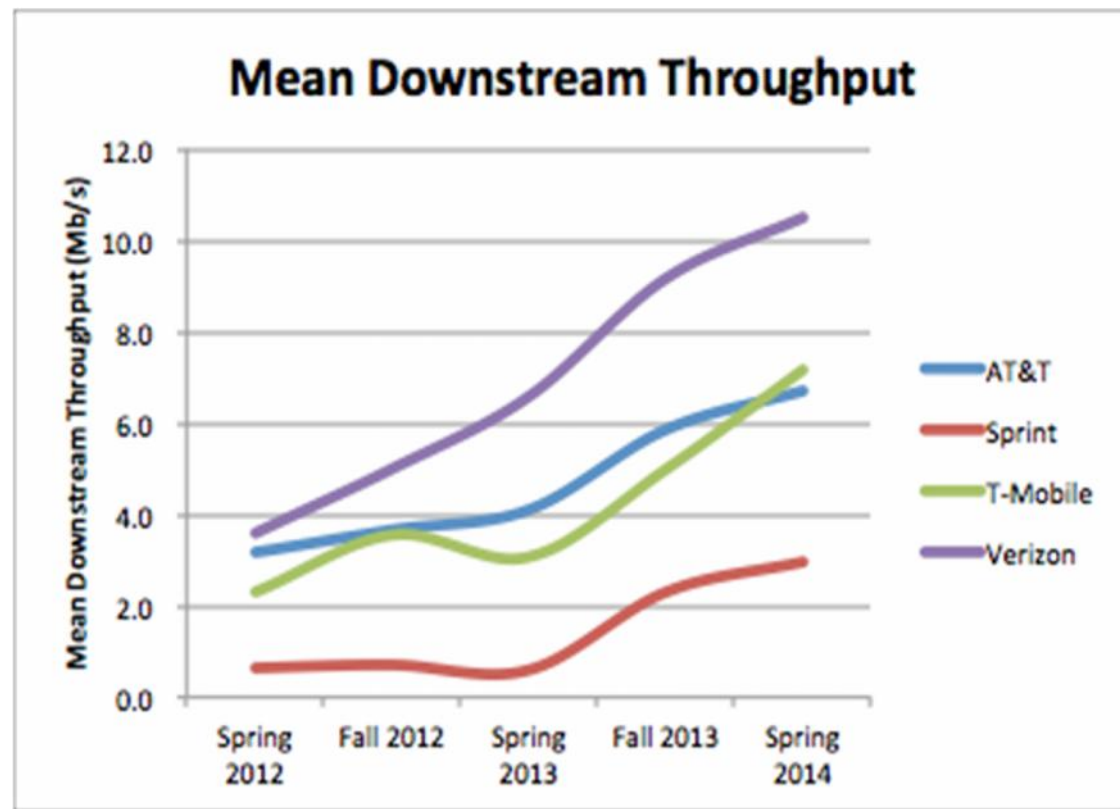
Not All Carriers Are Equal

- Wide variation in coverage
- Disparity in broadband service
 - Between carriers
 - Between urban/rural/tribal



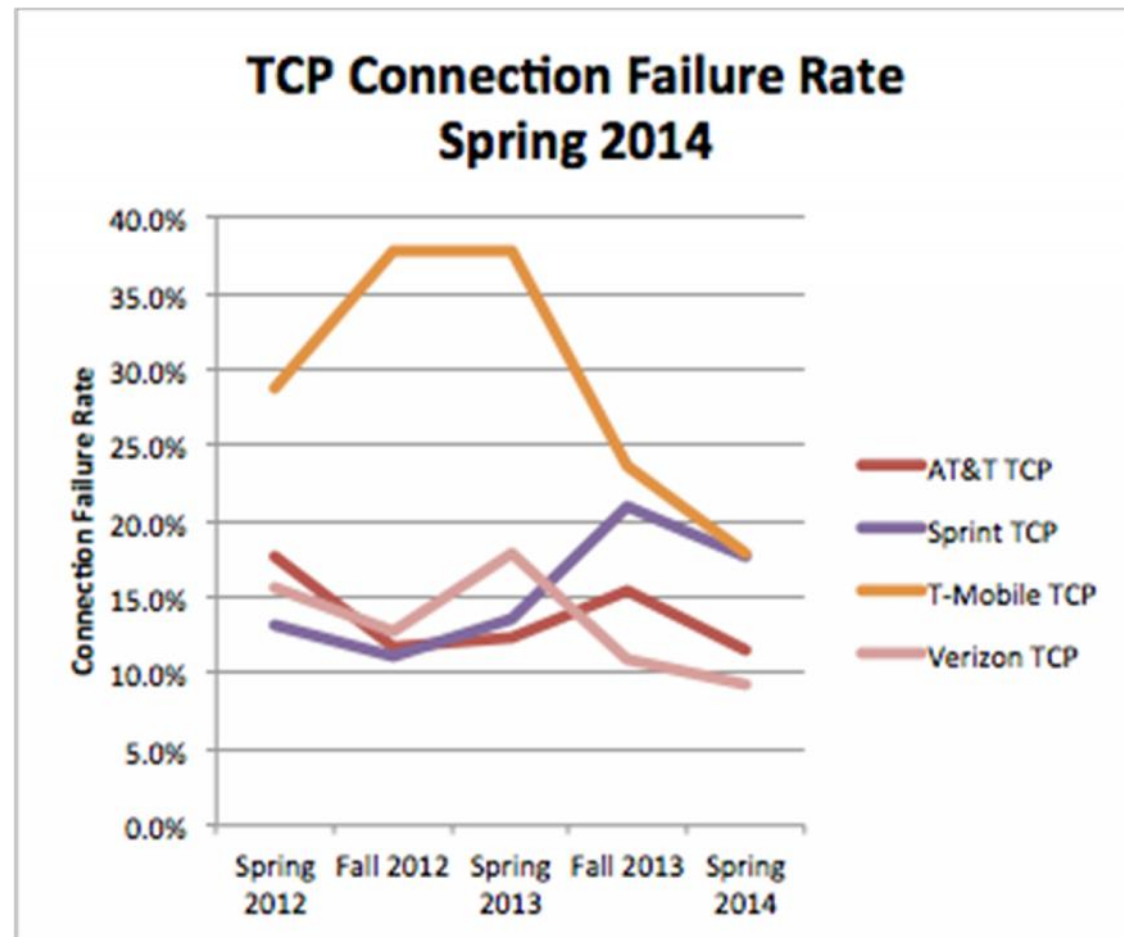
Not All Carriers Are Equal

- Wide variation in coverage
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 - Between urban/rural/tribal
- Throughput
 - 5x between best and worst



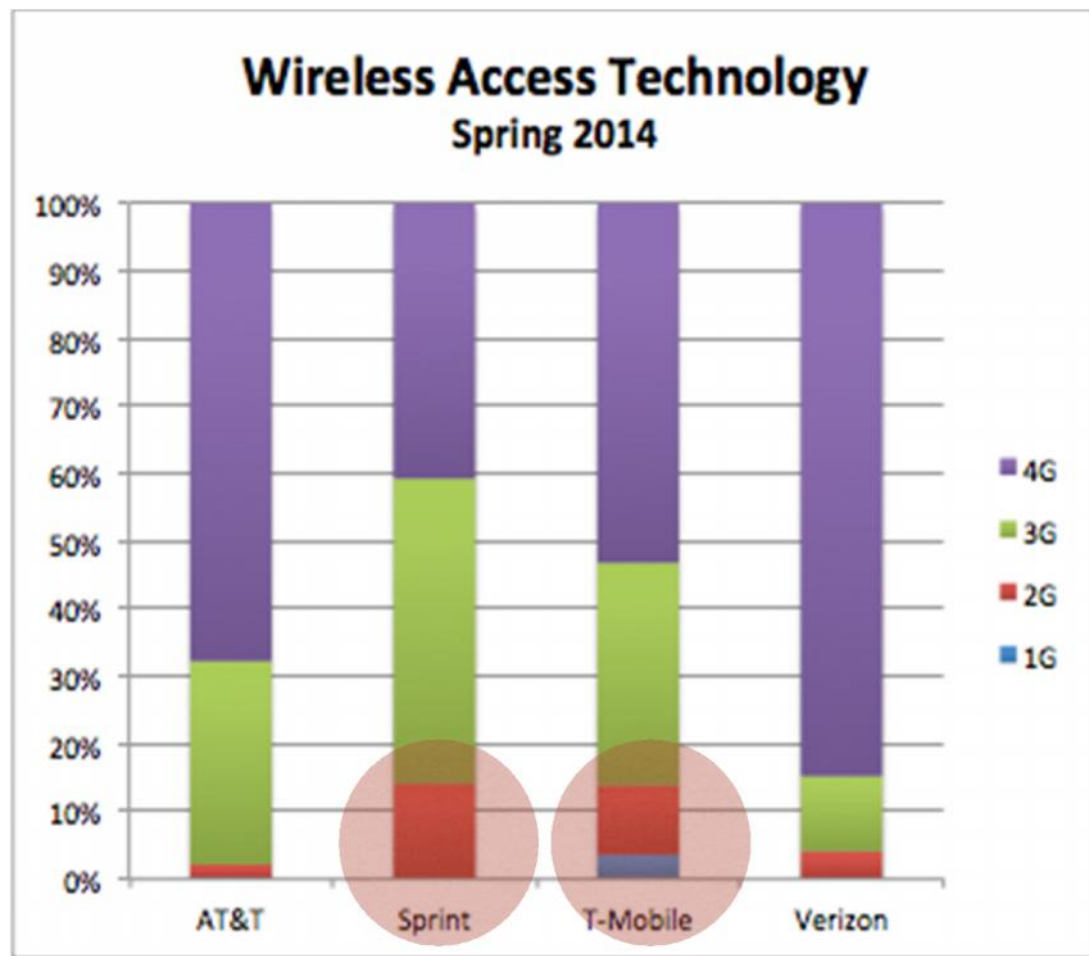
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- Wide variation in coverage
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- Throughput
 - 5x between best and worst
- Quality
 - 2x difference in TCP connection failure rates



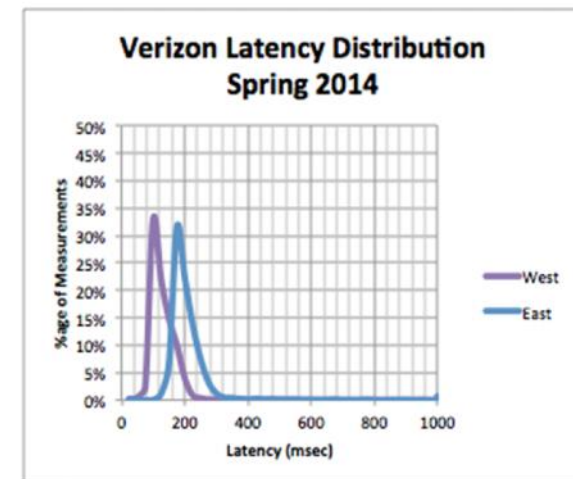
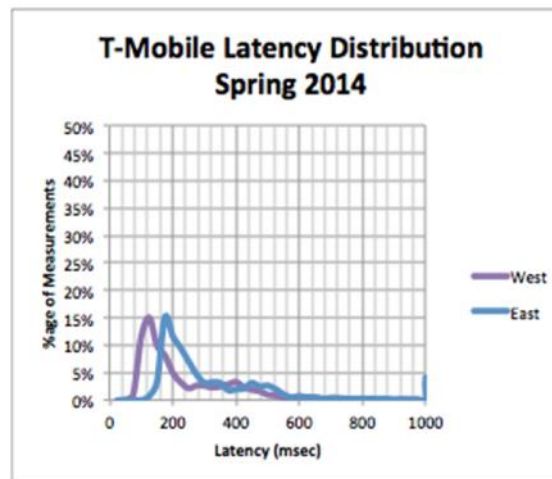
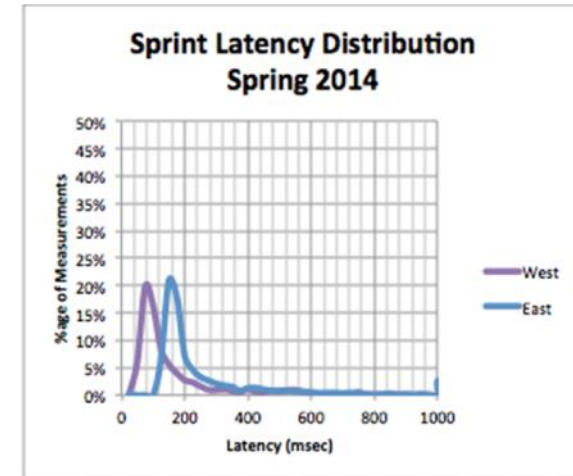
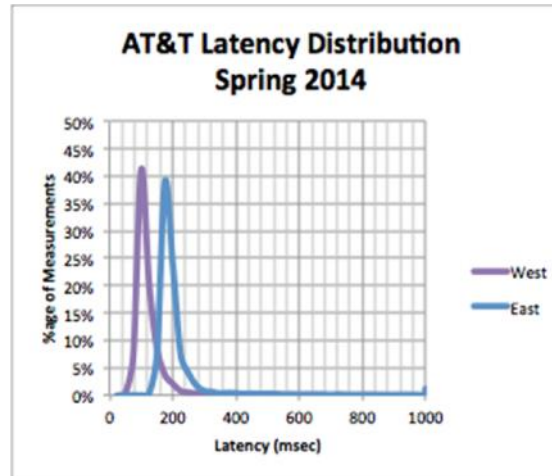
Not All Carriers Are Equal

- Wide variation in coverage
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 - Between carriers
 - Between urban/rural/tribal
- Throughput
 - 5x between best and worst
- Quality
 - 2x difference in TCP connection failure rates
- Technology
 - Legacy 1/2G wireless access technology particularly in rural/tribal



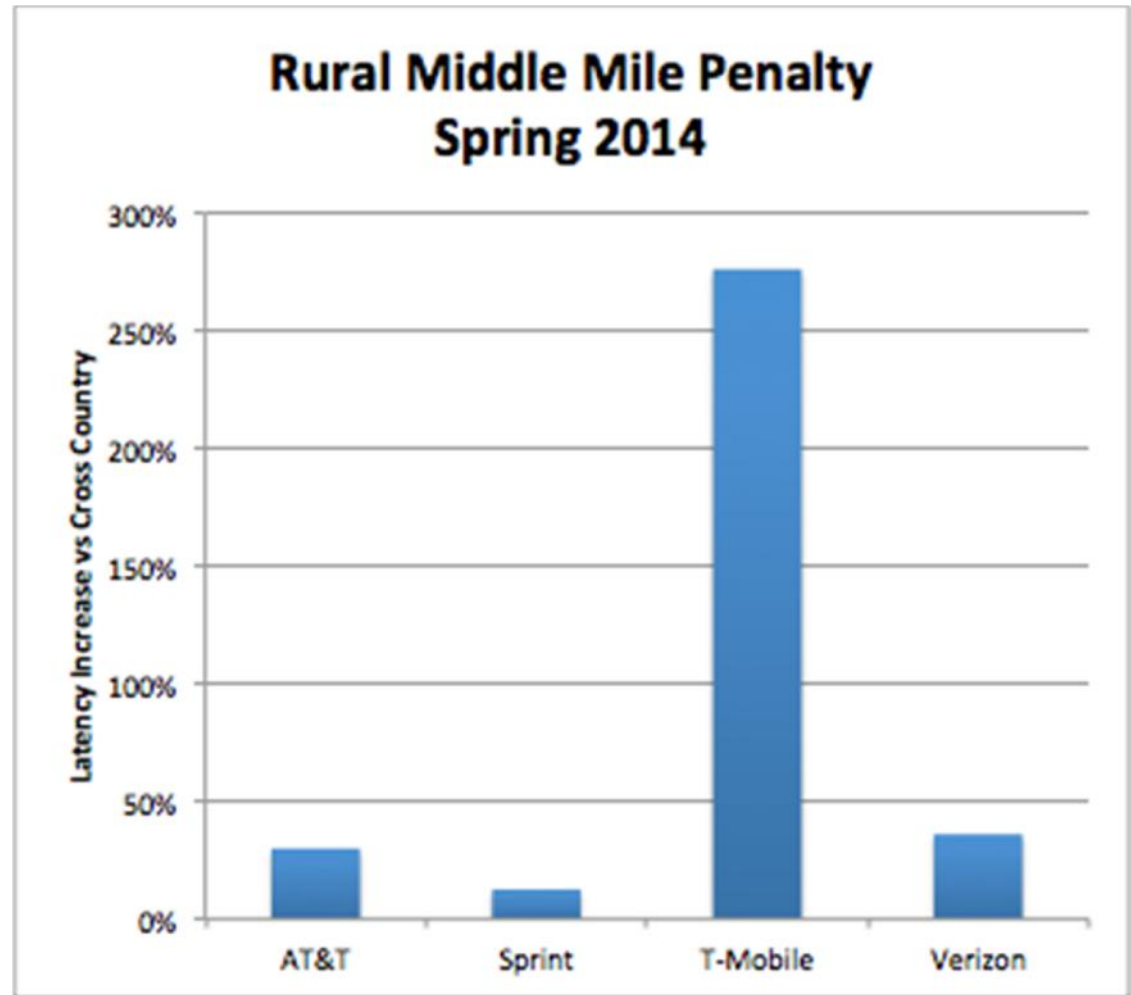
Mobile Broadband Not Just Wireless

- Latency is the key driver of Internet performance
 - Lower latency yields higher throughput, better streaming media
- Latency comes from the aggregate path from user to service
 - Wireless access
 - Middle mile
 - Internet transport
- Crossing the US is a 2x latency penalty (rural/urban/tribal)
 - This becomes a 25-40% throughput penalty



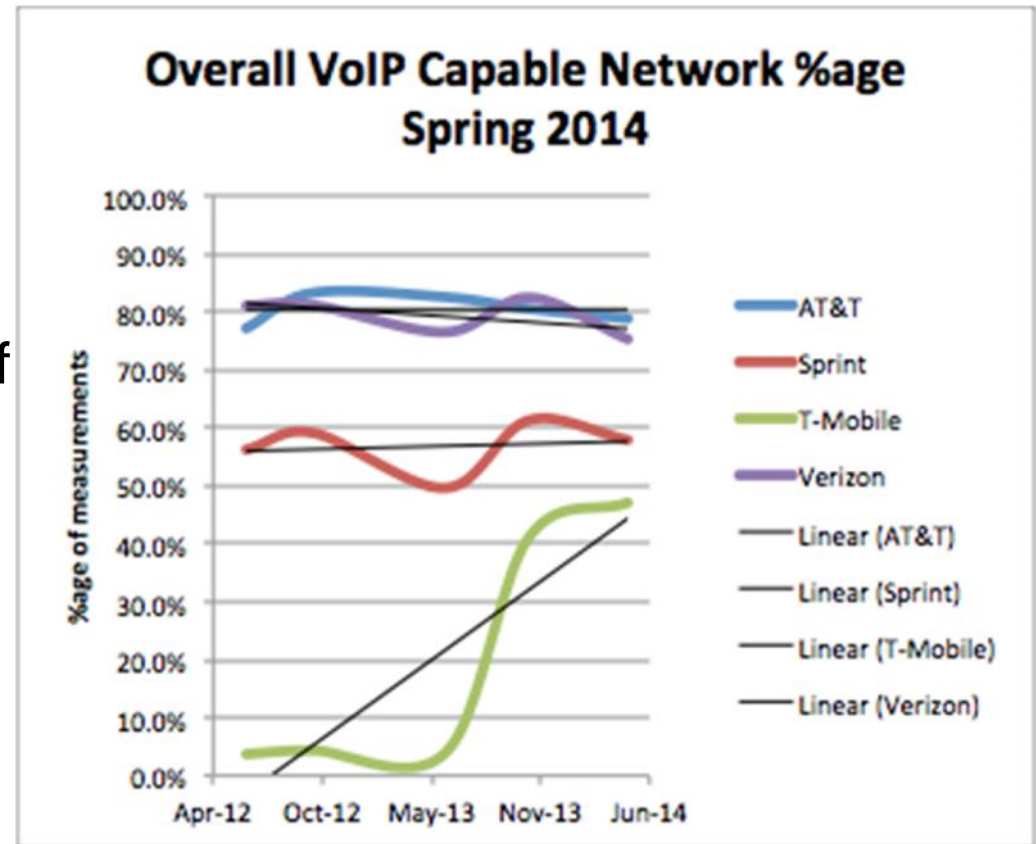
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- Crossing the US is a 2x latency penalty (rural/urban/tribal)
 - This becomes a 25-40% throughput penalty
- Crossing California for rural users is ~1.4x latency penalty over urban users
 - ~10-15% throughput penalty
 - Rural middle mile penalty



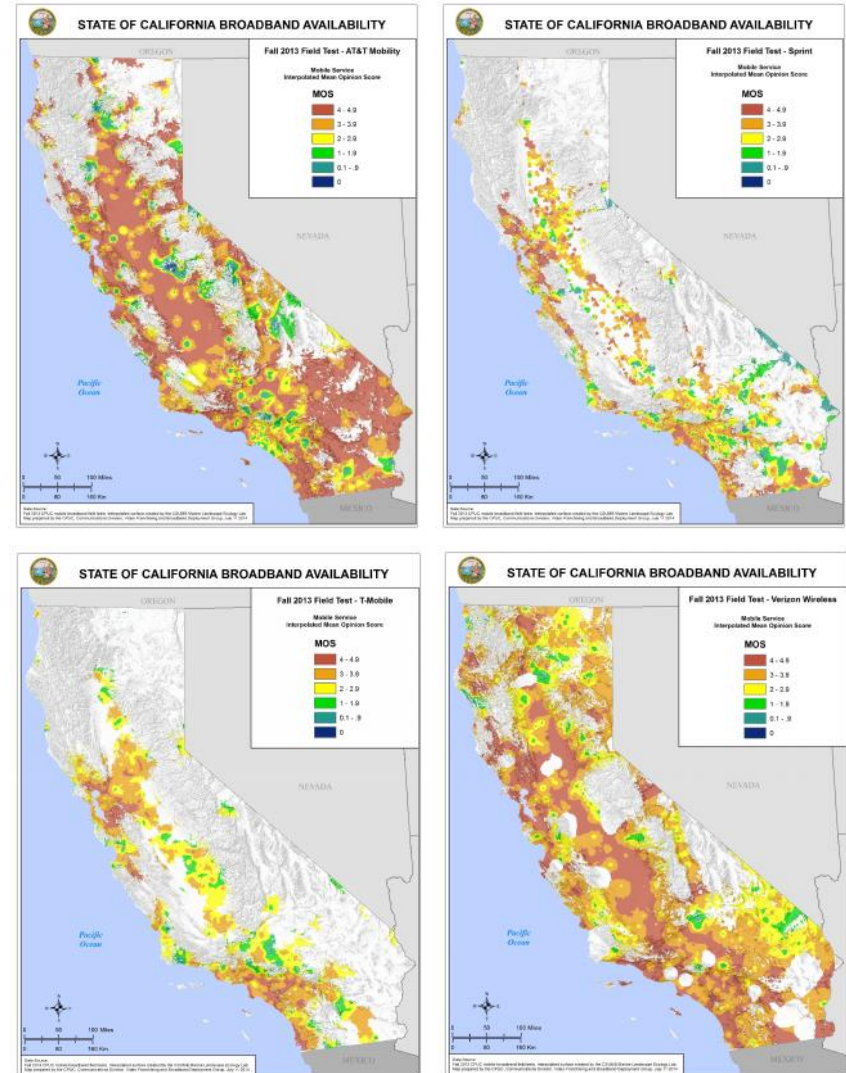
California's Mobile Networks not yet VoIP Ready

- VoIP Quality is Synthesis
 - Throughput
 - Latency
 - Jitter
 - Packet loss
- Mean Opinion Score is metric of voice quality
 - ≥ 4.0 is "toll quality" VoIP
- Overall networks not ready
 - AT&T and Verizon
 - ~80% of networks VoIP ready
 - Sprint: ~60%
 - T-Mobile: ~45%



California's Mobile Networks not yet VoIP Ready

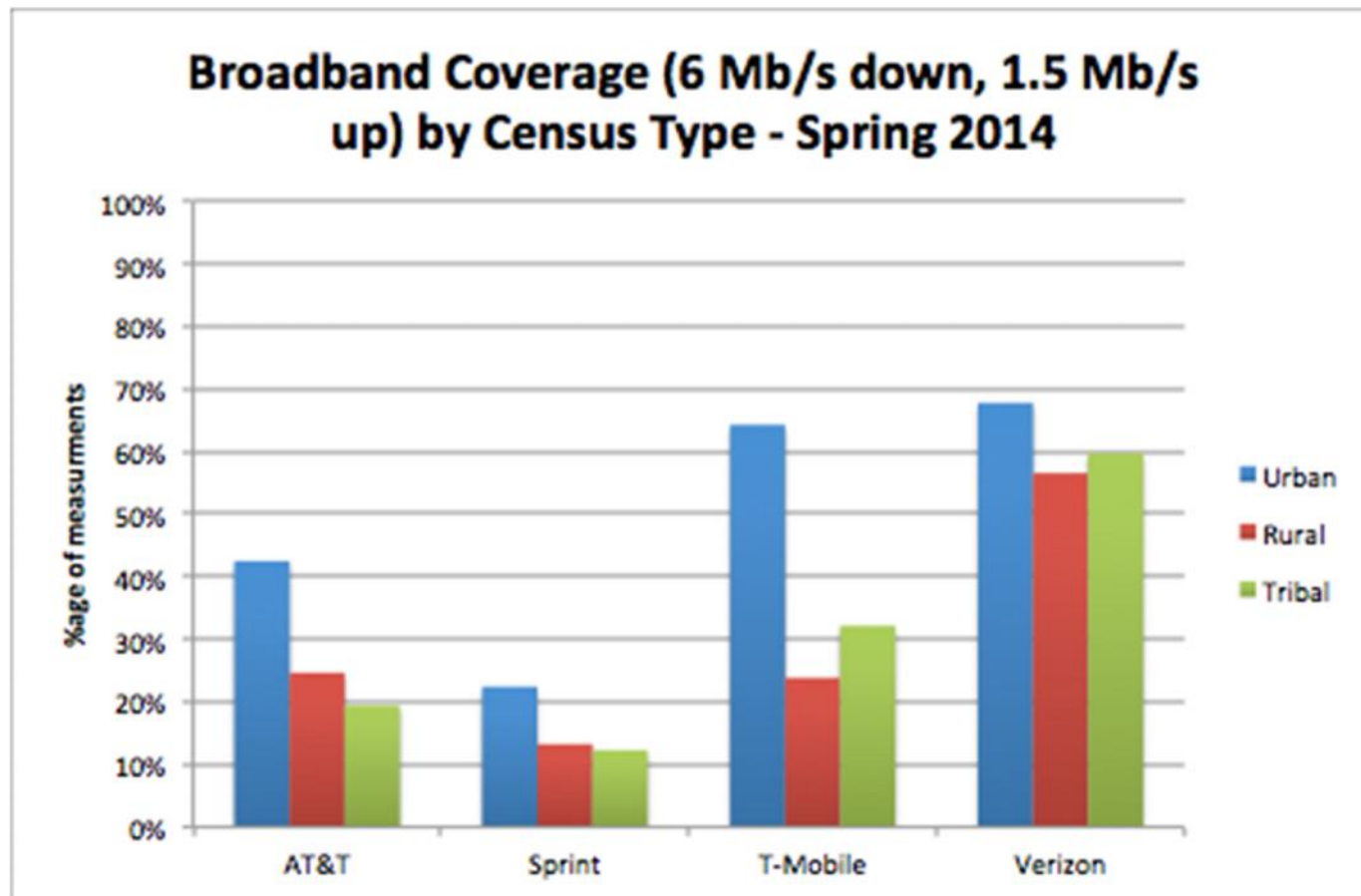
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 - AT&T and Verizon
 - ~80% of networks VoIP ready
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- Rural/Tribal materially worse



Real and Growing Mobile Digital Divide

Mobile Broadband Materially Worse in Rural/Tribal

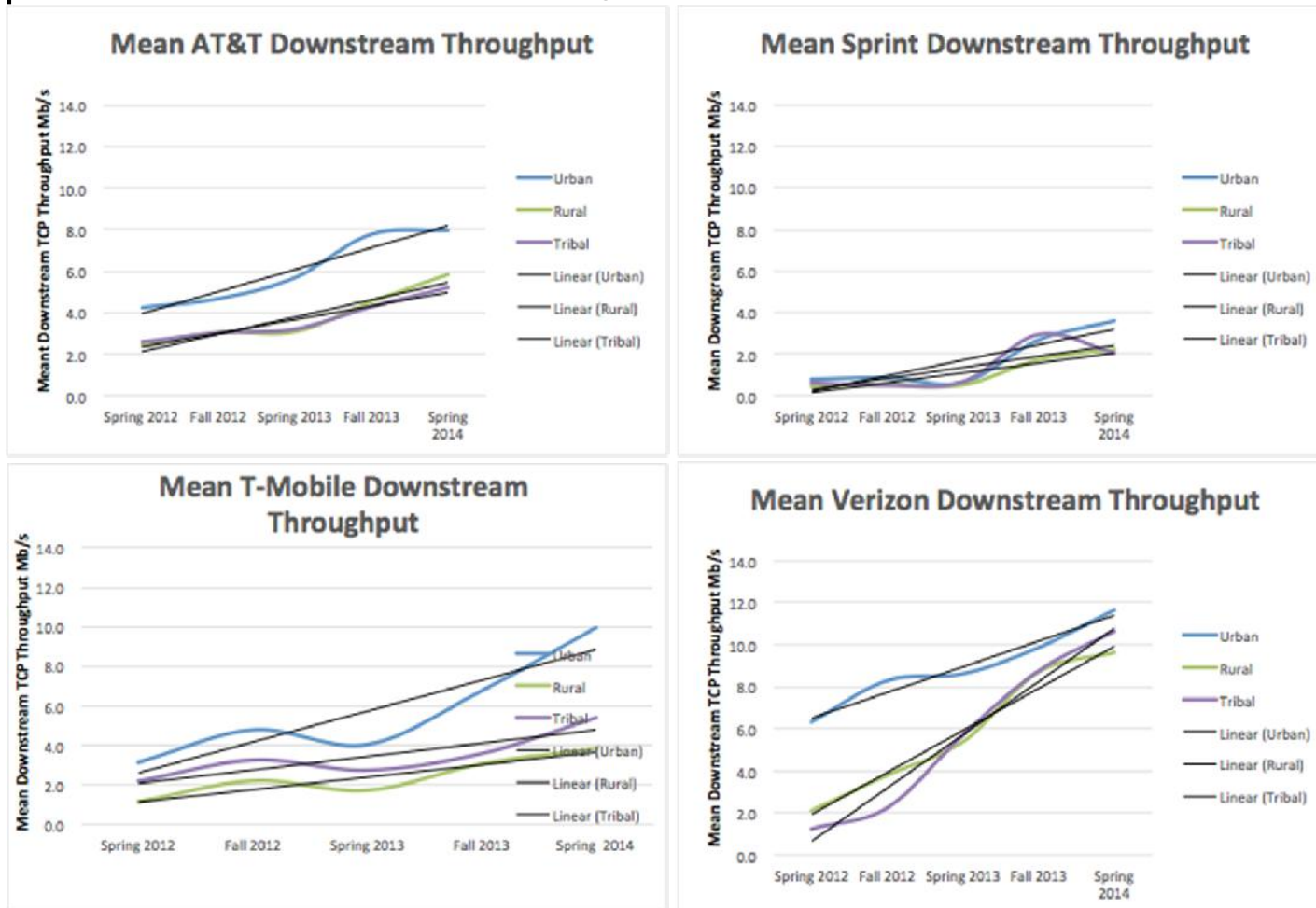
- Coverage - Rural/Tribal locations achieve broadband service levels half as often as Urban



Real and Growing Mobile Digital Divide

Mobile Broadband Materially Worse in Rural/Tribal

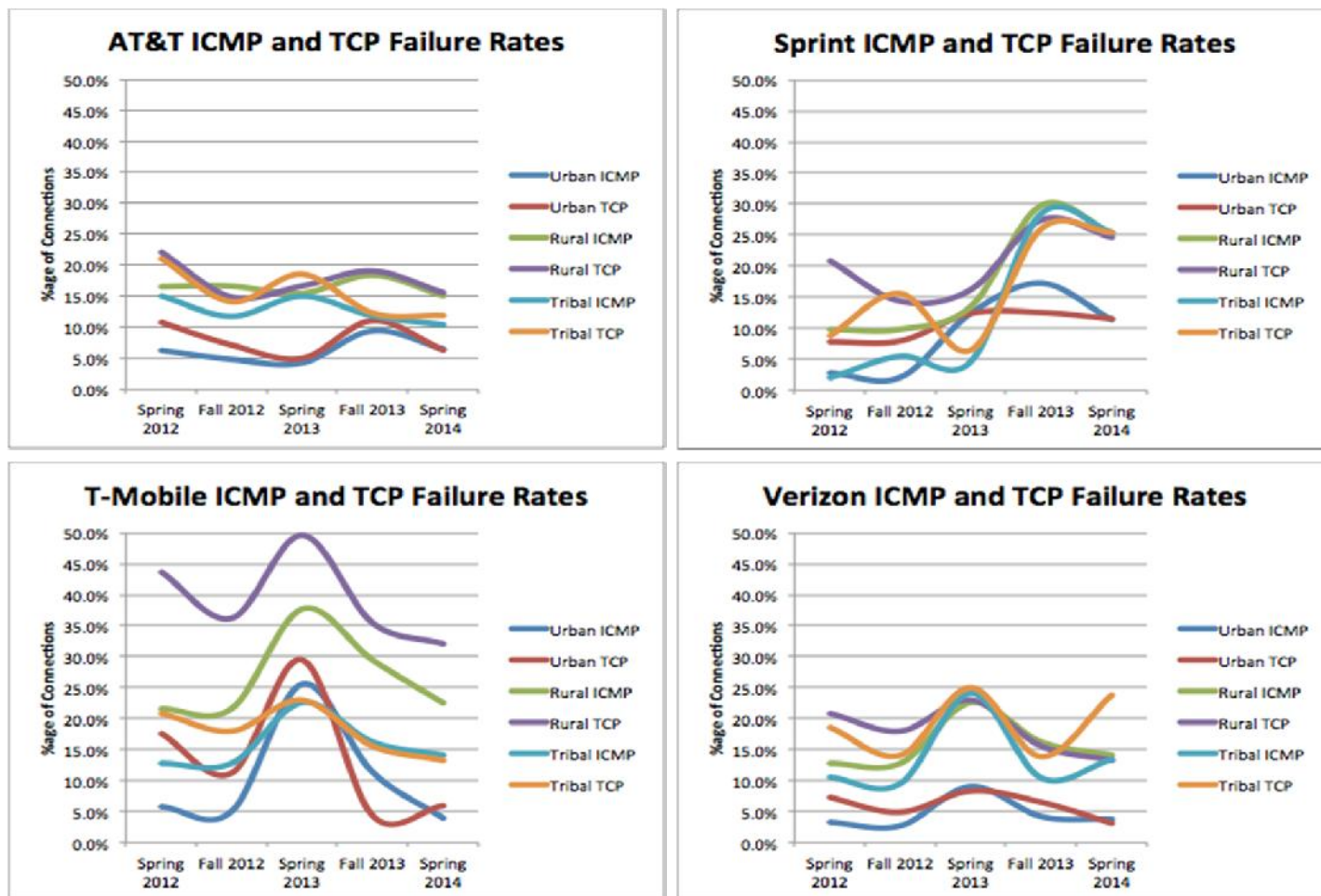
- Throughput - Rural/Tribal have half the throughput of Urban



Real and Growing Mobile Digital Divide

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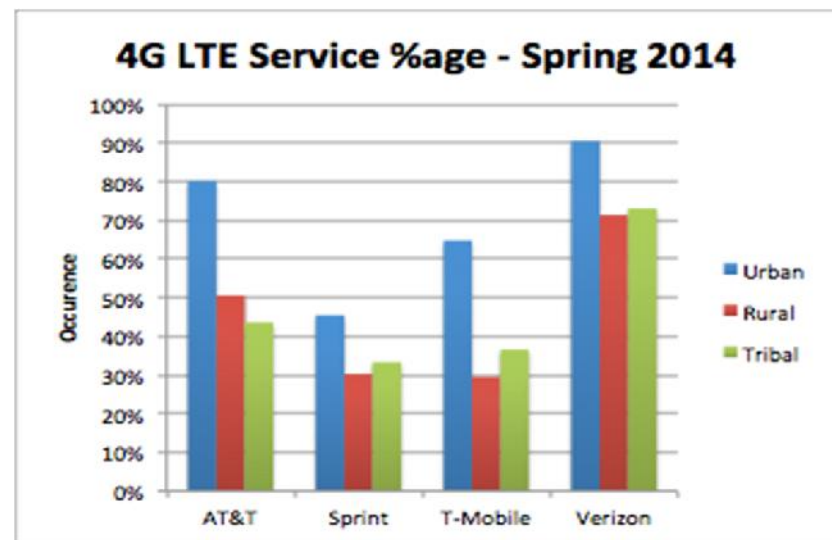
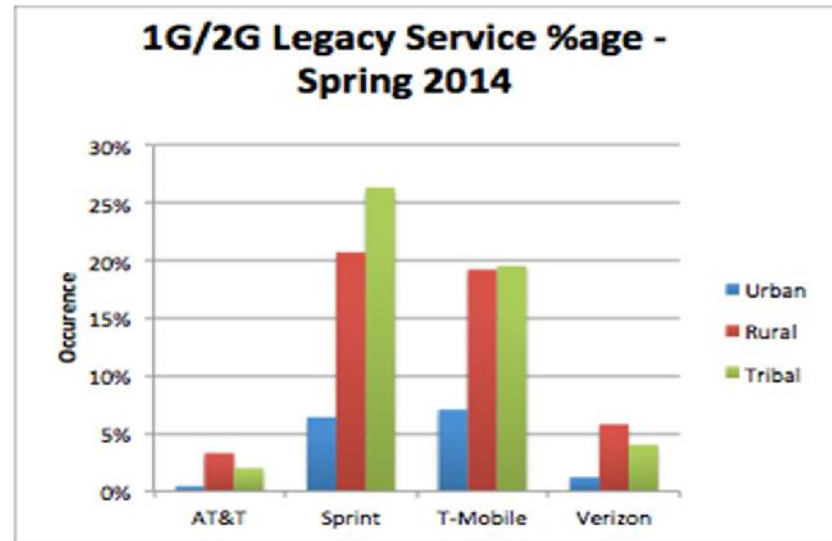
- Quality - Rural/Tribal TCP connections fail twice as often as Urban



Real and Growing Mobile Digital Divide

Mobile Broadband Materially Worse in Rural/Tribal

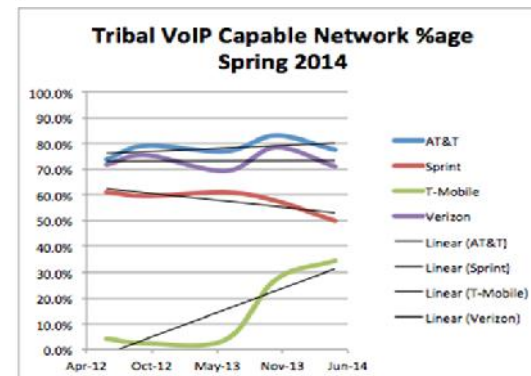
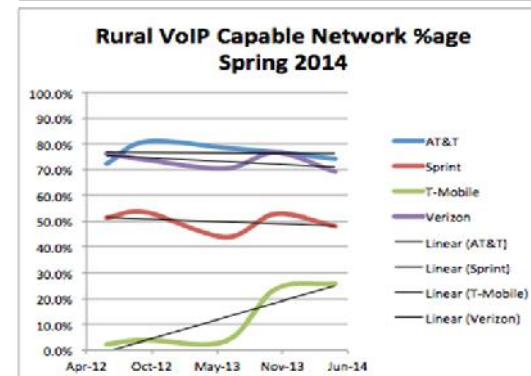
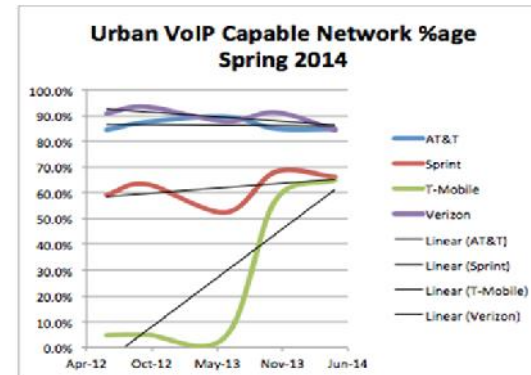
- Obsolete wireless access technology
 - ~1 out of 5 rural and tribal wireless connections on Sprint and T-Mobile made using technology considered old when the first iPhone introduced (2007)



Real and Growing Mobile Digital Divide

Mobile Broadband Materially Worse in Rural/Tribal

- VoIP quality materially worse
 - Best carriers (AT&T and Verizon)
 - ~15% worse than urban
 - Worst carriers (Sprint and T-Mobile)
 - ~35% worse than urban (Sprint)
 - ~50% worse than urban (T-Mobile)
- Gap increasing, in some way, for every carrier

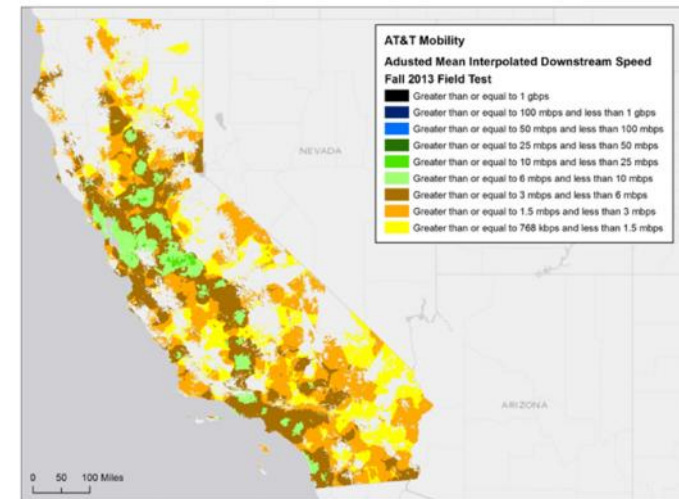
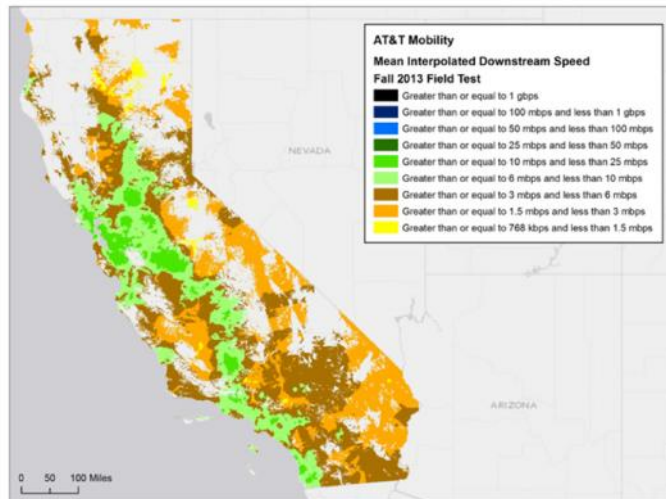
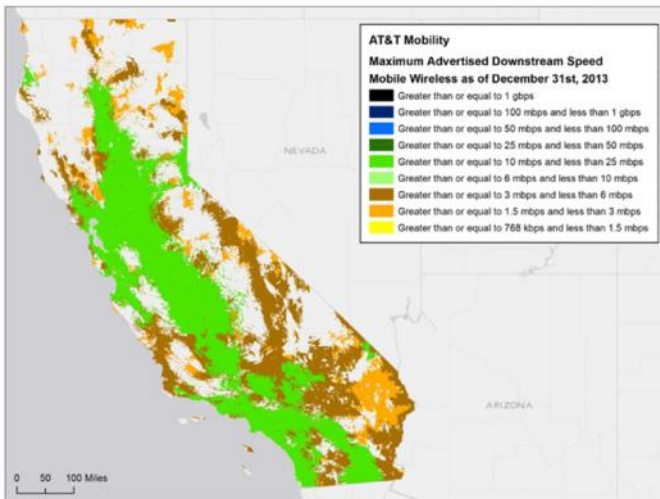


Measured Service vs Advertised Service - AT&T

Advertised Max

Measured Mean

Measured Mean
minus 1 Std Dev

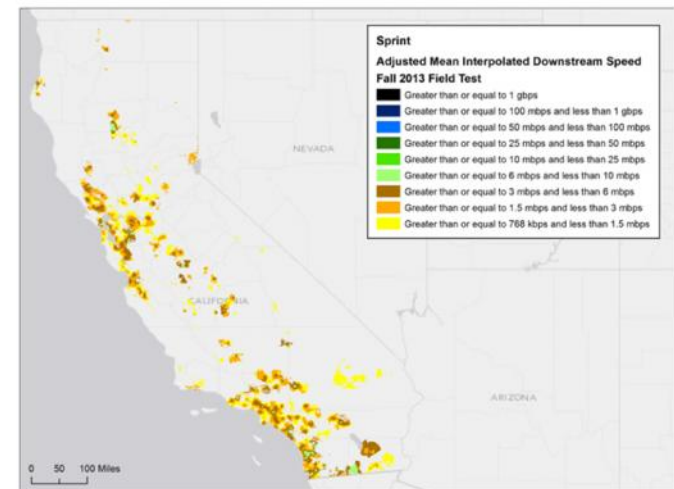
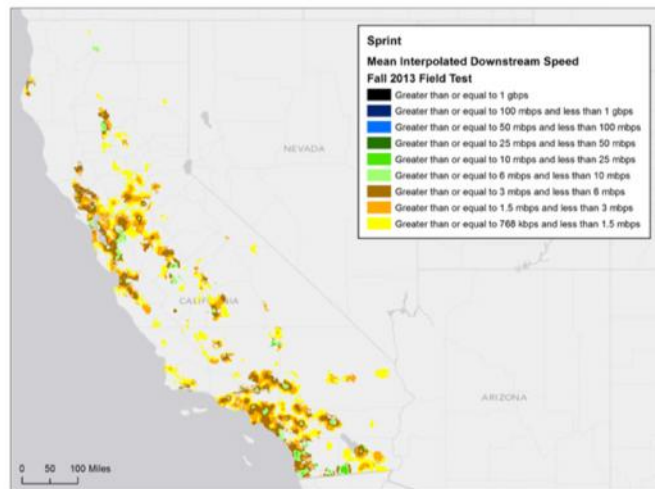
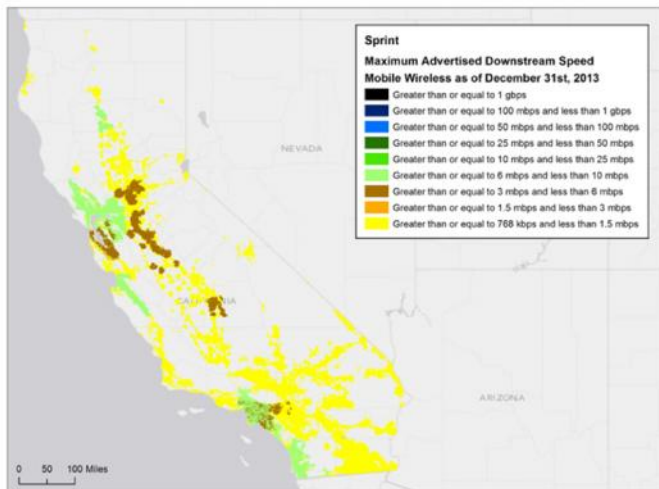


Measured Service vs Advertised Service - Sprint

Advertised Max

Measured Mean

Measured Mean
minus 1 Std Dev

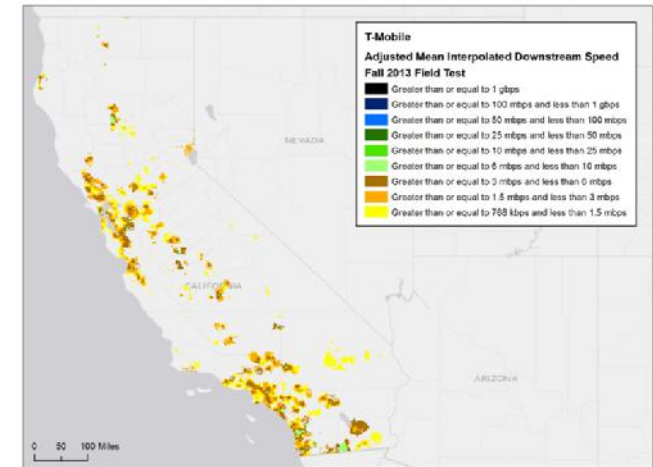
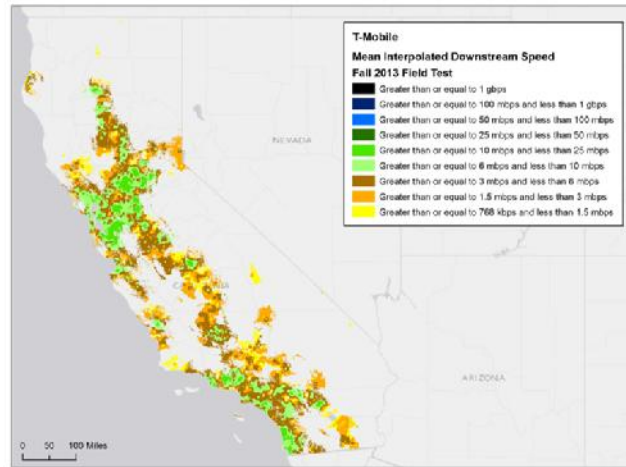
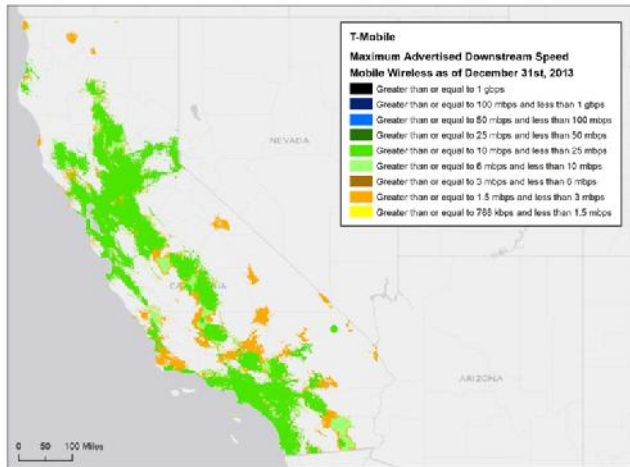


Measured Service vs Advertised Service - T-Mobile

Advertised Max

Measured Mean

Measured Mean minus 1 Std Dev

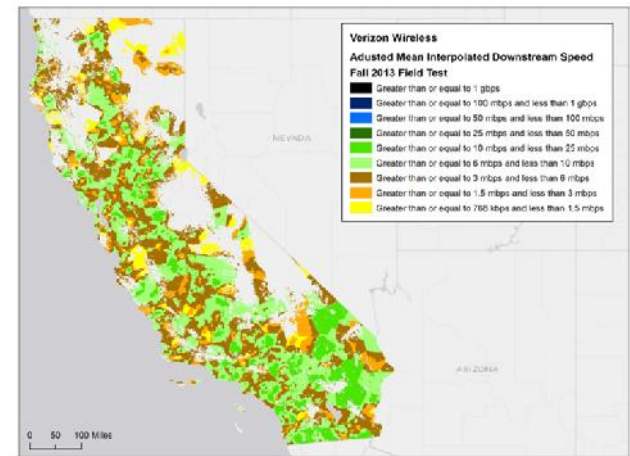
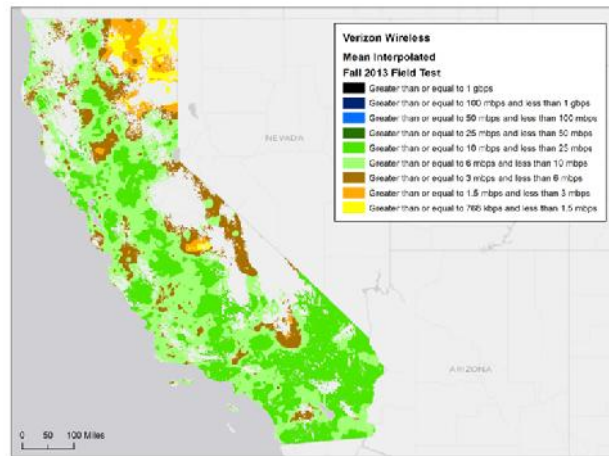
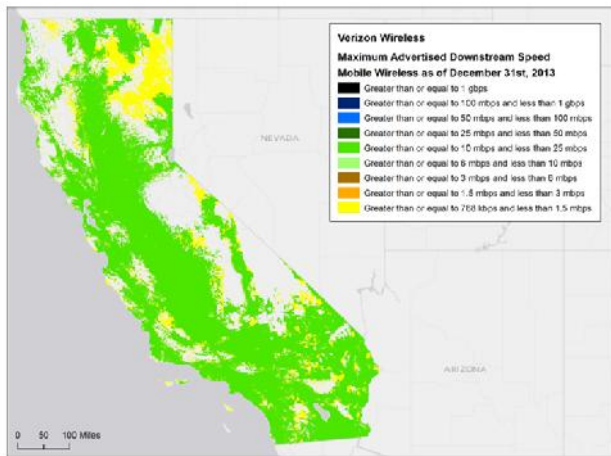


Measured Service Less Than Advertised - Verizon

Advertised Max

Measured Mean

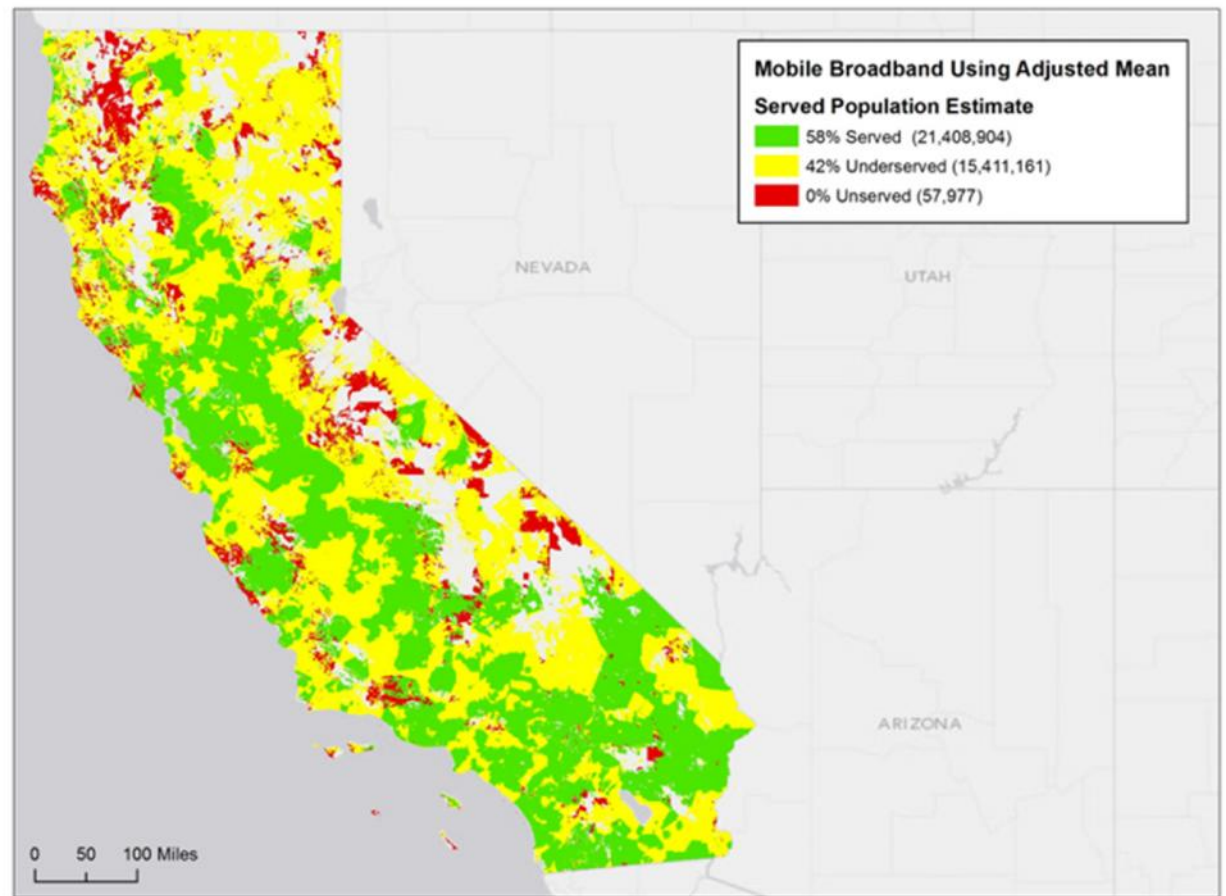
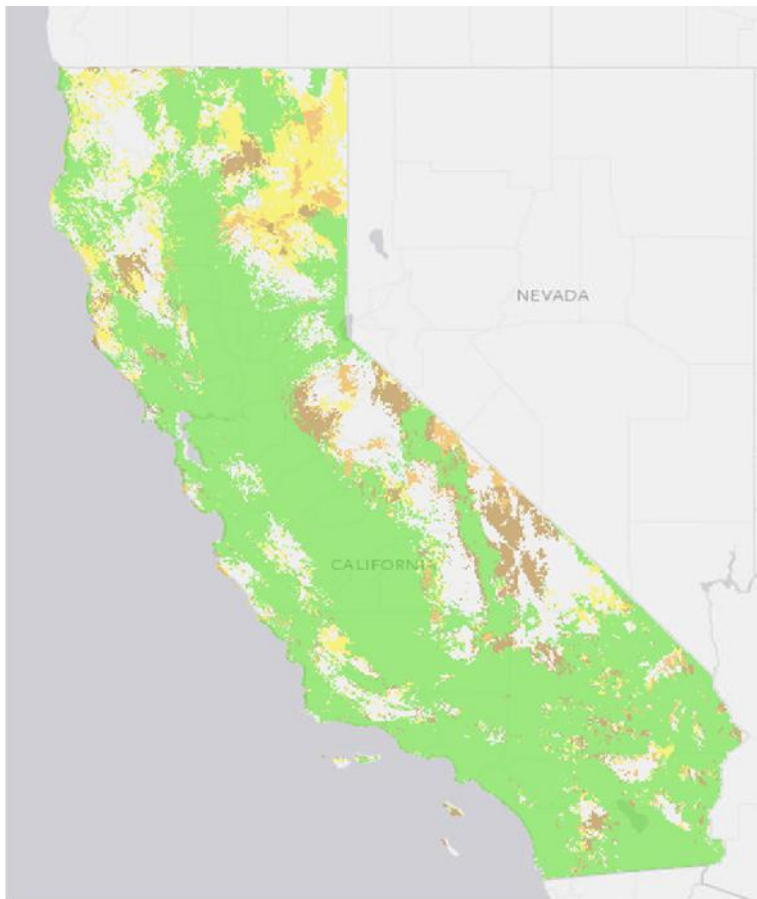
Measured Mean
minus 1 Std Dev



Mobile Measured Served vs Advertised Served (all carriers)

Advertised Max

Measured Mean - 1 std dev



Six Key Themes

- Mobile broadband continues to get much better VERY quickly (on average)
- Wide variation in mobile broadband performance across California
- Not all carriers are equal
- Mobile broadband service is not just wireless access
- Real and growing mobile digital divide
- The bulk of the mobile network is not yet VoIP ready.
- Measured service is less than carrier's "advertised service"