

Expanding Mobile Wireless Capacity:

The Challenges Presented by Technology and Economics

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Rethinking Communications Policy for
a Mobile Broadband World*

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Overview of presentation

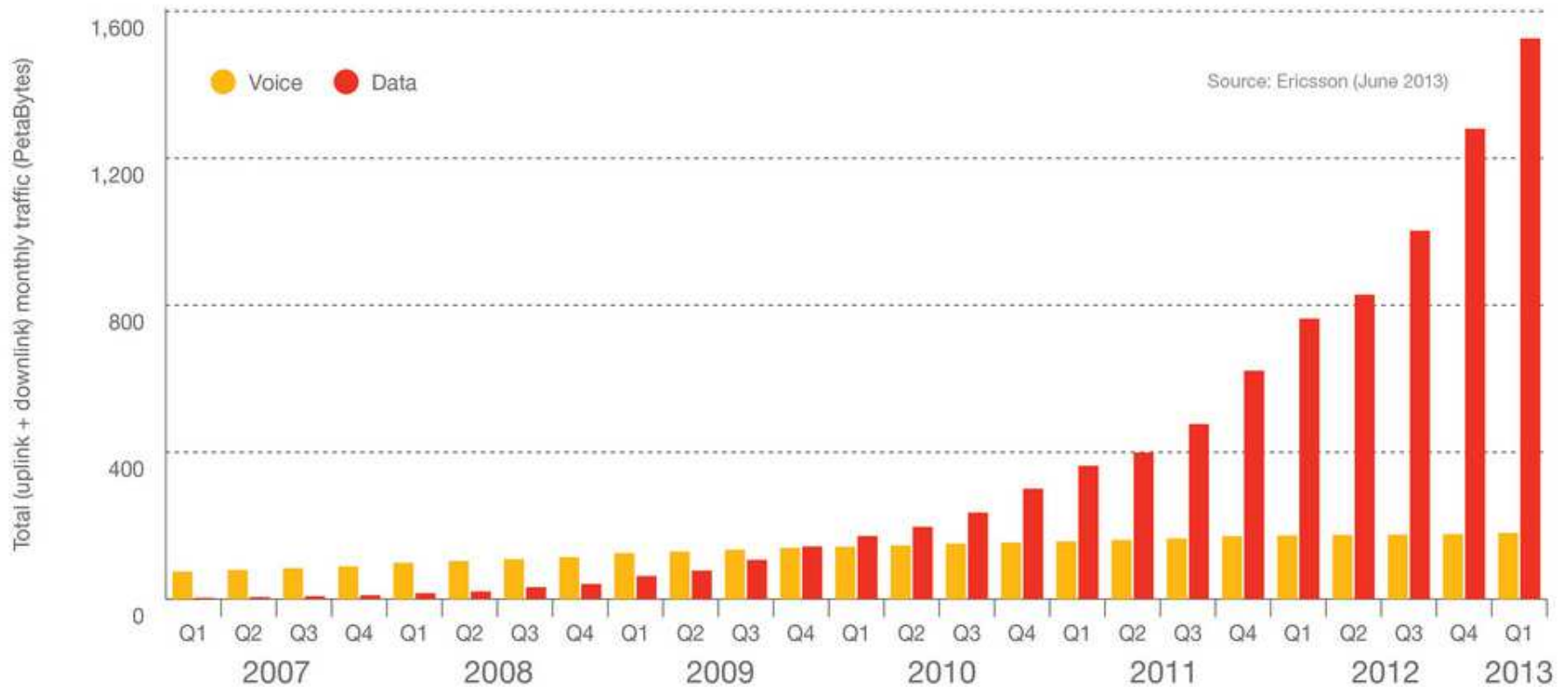
- What is the **challenge**?
- What **methods** are available to **expand capacity**?
 - How effective has each **been**?
 - How effective may they be in the **future**?
- Without much **more raw spectrum**, these methods will **not** be able to keep up with forecasted demand
- Alternatively, more severe **price adjustments** may be necessary to equilibrate the market

The analyses and data presented in this paper are intended to portray the U.S. mobile wireless industry on a national average basis. They may not be representative of any particular U.S. geographic region or mobile operator, including AT&T. No proprietary AT&T data were used in performing these analyses. The conclusions developed in this paper are those of the author, alone, and should not be construed as representing any official position of AT&T.

What is the challenge?

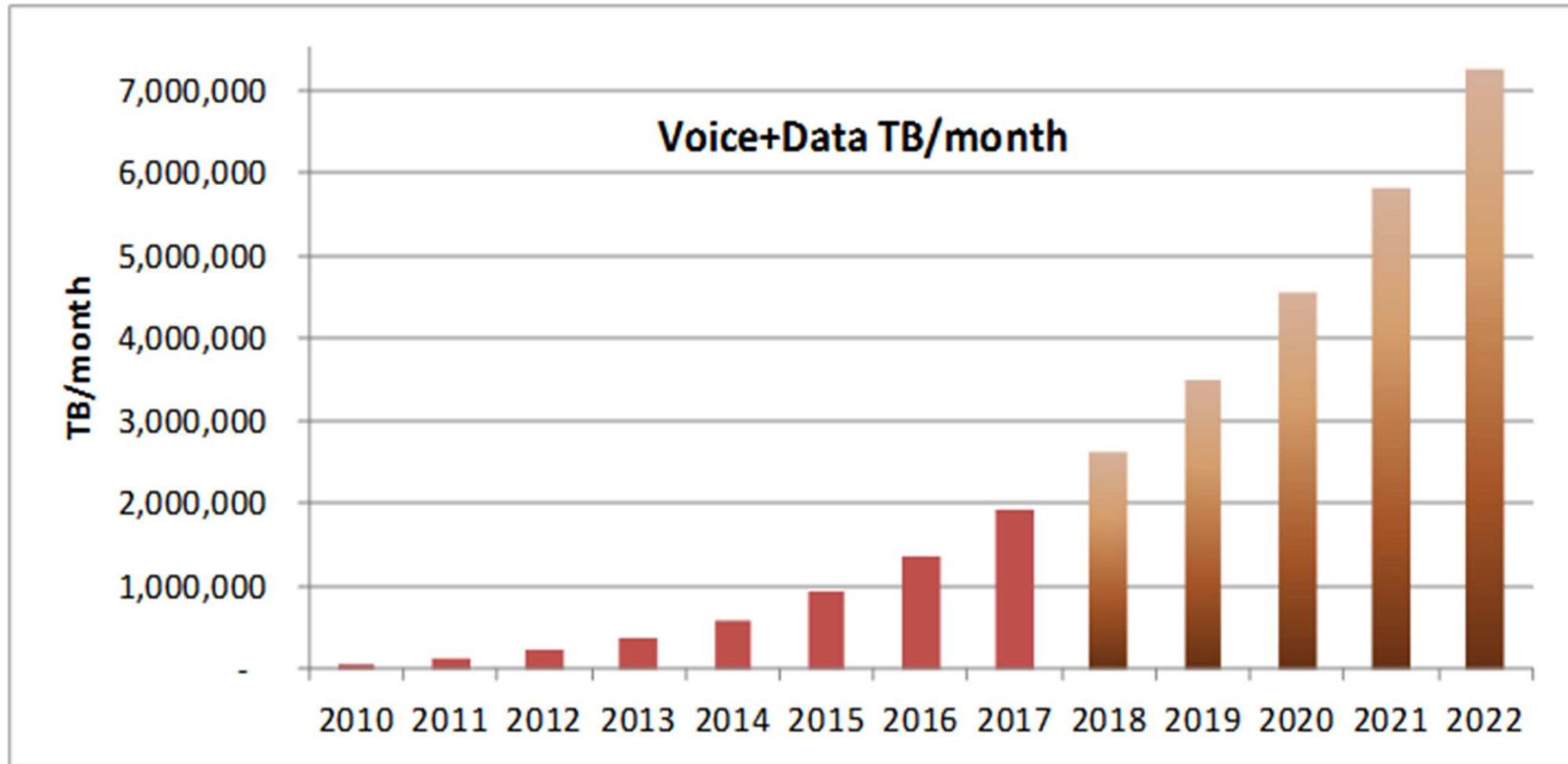
Rise in data usage is driving mobile demand

Total global traffic on mobile networks, 2007-2013



Notes: Reported *traffic does not include* DVB-H, Wi-Fi, or Mobile WiMax. Voice does not include VoIP. M2M traffic is not included.

And U.S. forecasts predict this to continue



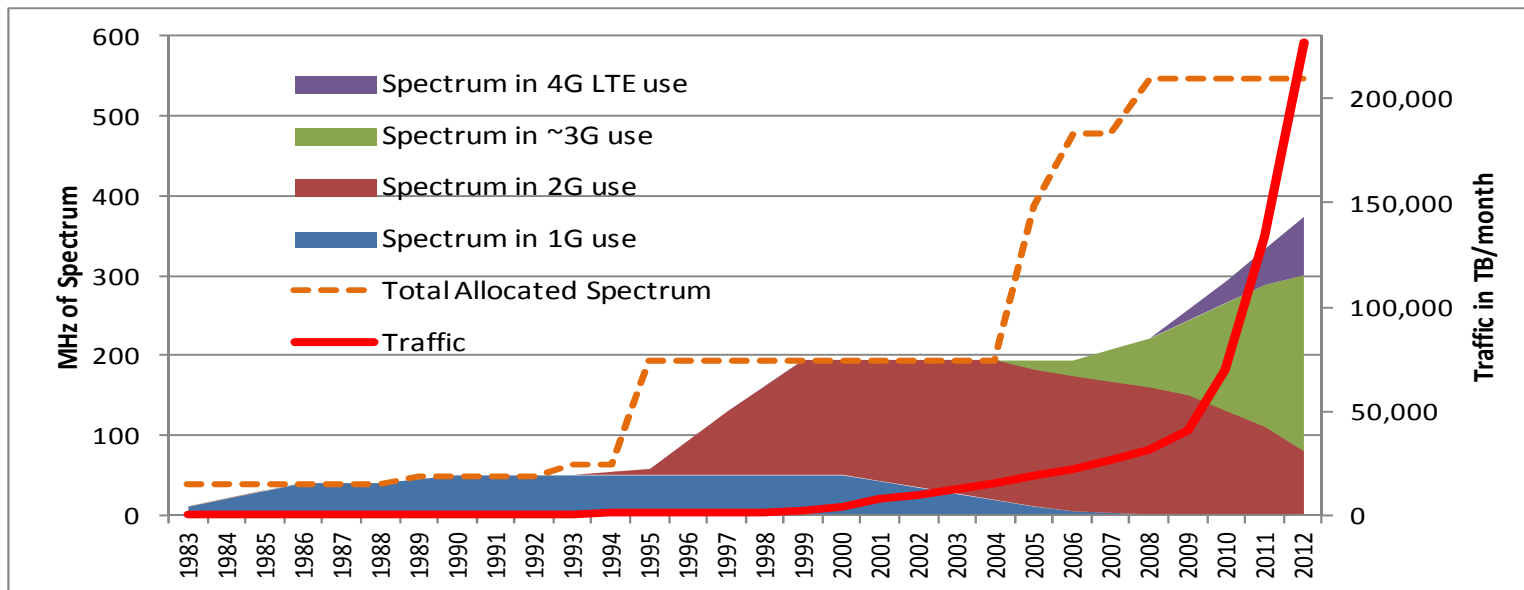
Notes: Voice and Data TB figures for 2010-2012 are from Fig. 1. Forecasted 2013-2022 Voice demand growth assumes Voice TB remain flat at 2012 levels. Cisco (2013) figures for Data TB are used for 2013-2017 Data demand. These Data TB figures are extrapolated forward for 2018-2022 assuming that Cisco's forecasted demand growth rate for 2016-17 decays by 10% each year over the 2018-2022 period.

What are the tools to address growing demand?

More spectrum

- By deploying **more radio spectrum**, capacity is increased
- But the spectrum usable for mobile wireless is **very scarce**
 - It is being used for **TV** or by the **government**
 - These entities have had **little economic incentive** to relinquish it

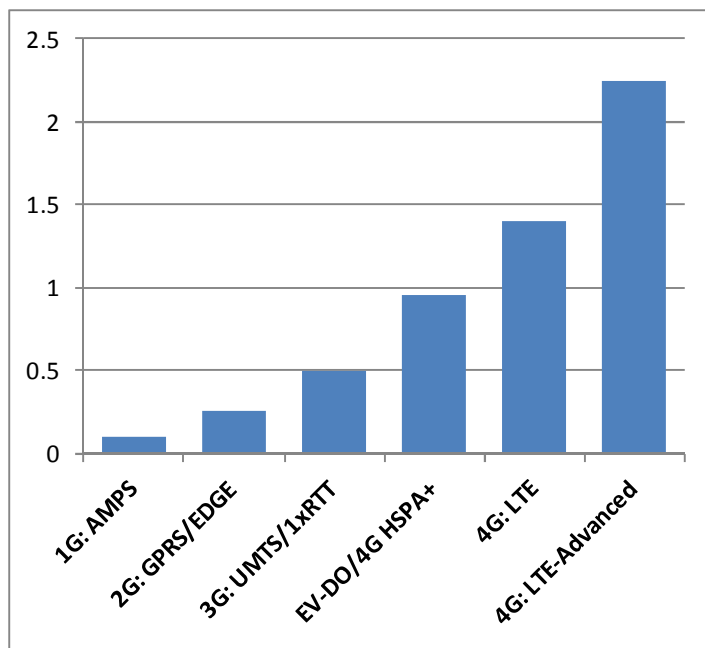
U.S. Spectrum Growth



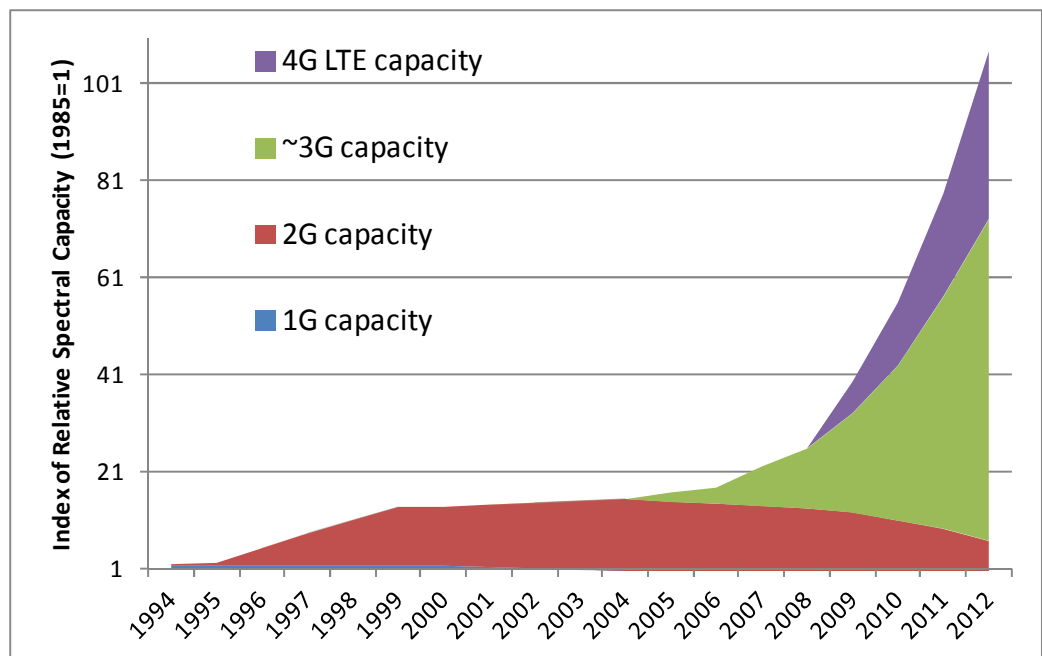
More spectrally efficient technologies

- Newer wireless technologies can carry **more bps/Hz**
- As customers are **migrated** to these technologies, more total traffic can be handled by a given amount of spectrum

Spectral Efficiency (bps/Hz)



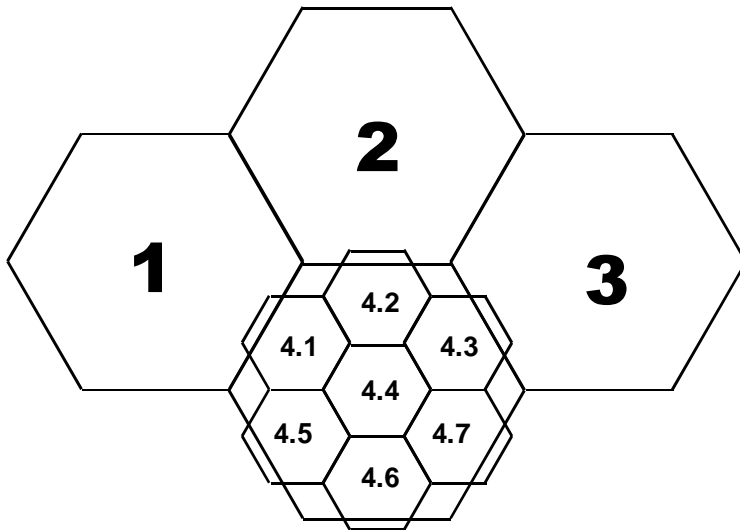
Growth of Effective Capacity



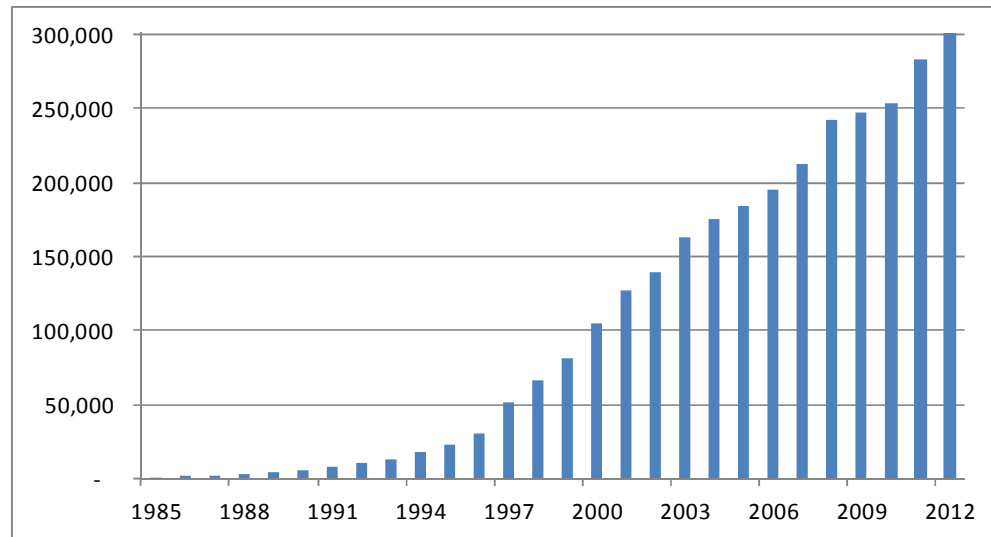
Increased “reuse” of spectrum

- By deploying **more towers** and **splitting cells**, capacity within a geographic area is increased by “**reusing**” spectrum
- This has been done intensively, but it is **expensive** as its cost scales fairly linearly with cell counts

Cell Splitting



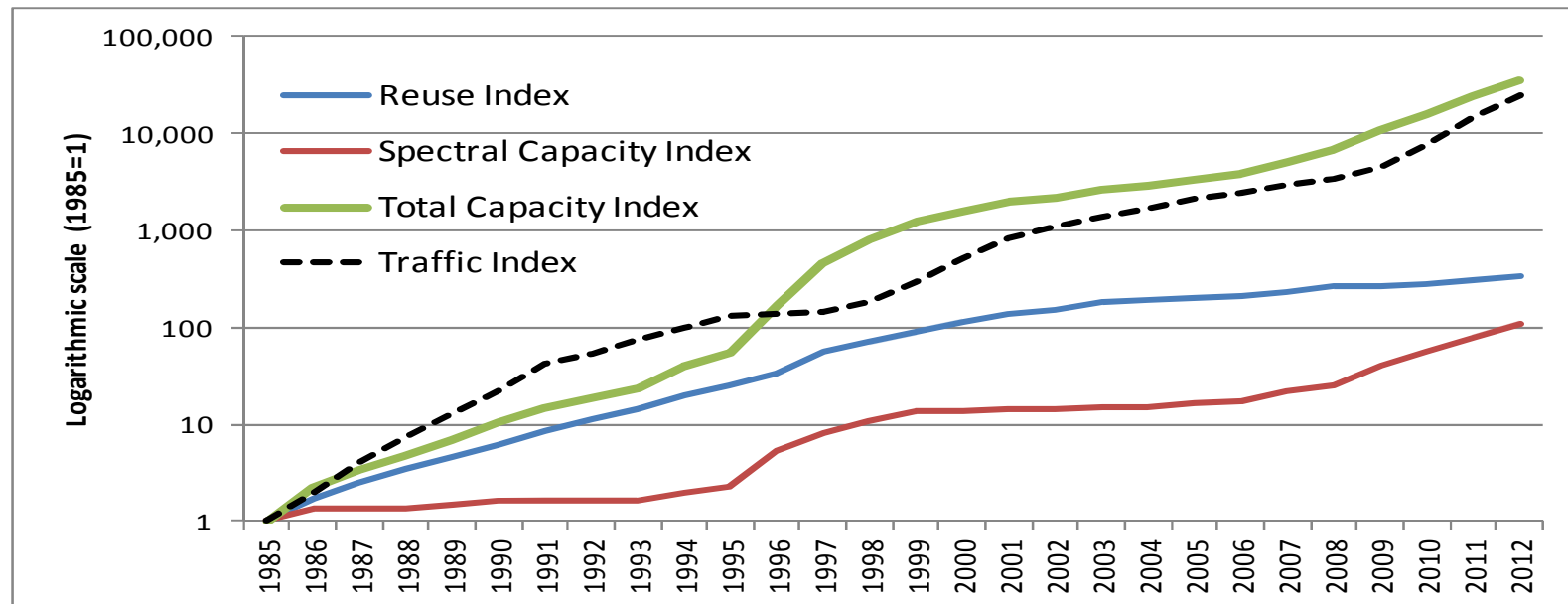
U.S. Cell Site Growth



Relative contributions

- Historically, more **spectrum**, more **efficient technologies** and **increased reuse** have allowed capacity growth to keep pace with traffic demand, but this is about to **change**

Capacity growth relative to traffic growth



Note: Displayed historical capacity index doesn't include improvements in network packing that may have occurred from 1985-2000.

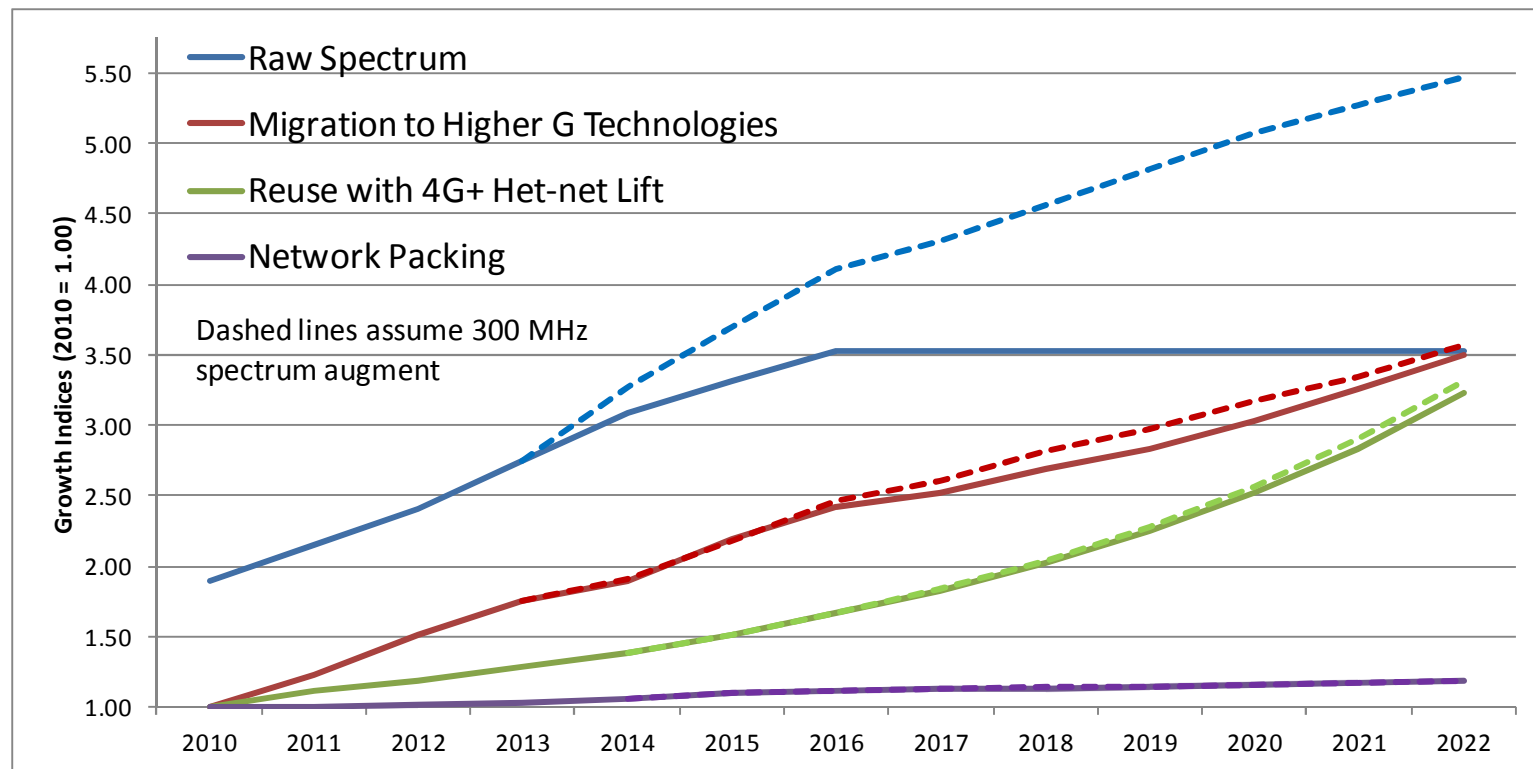
Will future tools be adequate?

4G LTE and LTE-Advanced

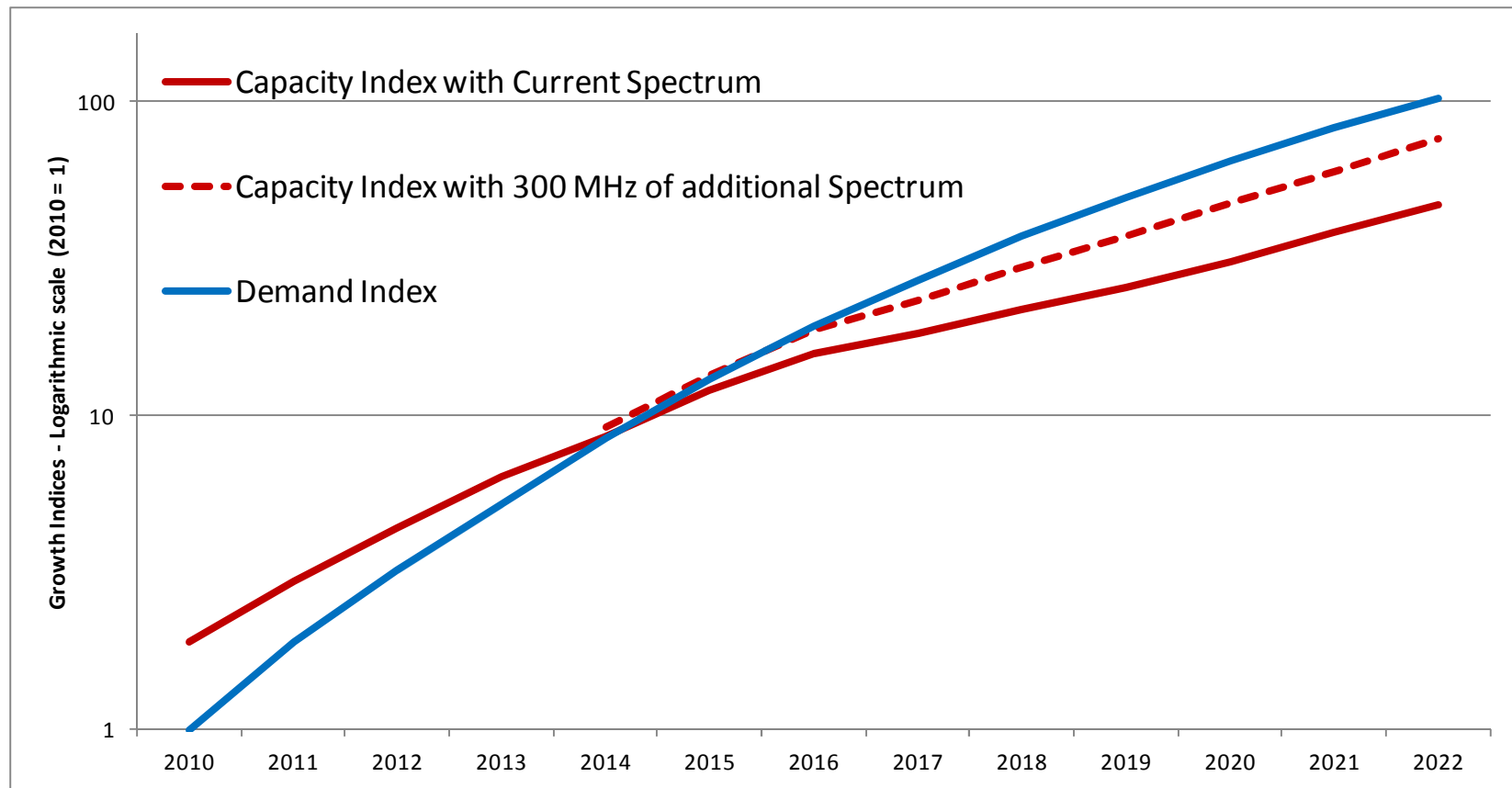
- These technologies offer substantial **improvements** through:
 - Orthogonal frequency division multiple access (**OFDMA**)
 - Multiple input multiple output (**MIMO**) transmissions
 - Coordinated multipoint (**CoMP**) transmission/reception
- Lift in **spectral efficiency** over current ~3G is roughly 45% for LTE and 135% for LTE-Advanced
- Supports more functional **small cells** (Het-nets) which make more intensive spectrum reuse **more economic**
- Reduced latency permits **VoLTE** to replace separate voice networks, which enables more efficient **network packing**
- But LTE's higher throughput **speeds** and **lower latency** increase mobile wireless' **functionality** – which encourages further **usage growth!**

Contributions to future capacity growth

- 300 MHz more spectrum by 2015 is promised in the FCC's National Broadband plan, but so far little has been allocated



But all of these may still be inadequate



- Even with 300 MHz more spectrum, capacity does not keep up with expected demand growth

Summary

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- Mobile wireless technologies have become ever **more capable**
 - Faster **speeds**
 - Lower **latency**
 - Greatly improved data **carrying capacity**
- But demand is growing **even faster**
- Meeting the challenge will **require**:
 - Even more **capable technologies**; ***and***
 - Even more **intensive spectrum reuse**; ***and***
 - Much more **raw spectrum**
- The alternative is **price adjustments** to equilibrate the market, which may suppress **desirable usage growth**

Full paper available at: <http://ssrn.com/abstract=2197416>