Expanding Mobile Wireless Capacity:

The Challenges Presented by Technology and Economics

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The Broadband Technology Explosion: 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

Voice does not include VoIP. M2M traffic is not included.

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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



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

- 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; <u>and</u>
 - Even more intensive spectrum reuse; <u>and</u>
 - Much more raw spectrum
- The alternative is price adjustments to equilibrate the market, which may suppress desirable usage growth

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

