



***"Technological Solutions and Greater Use of Commercial Networks"***

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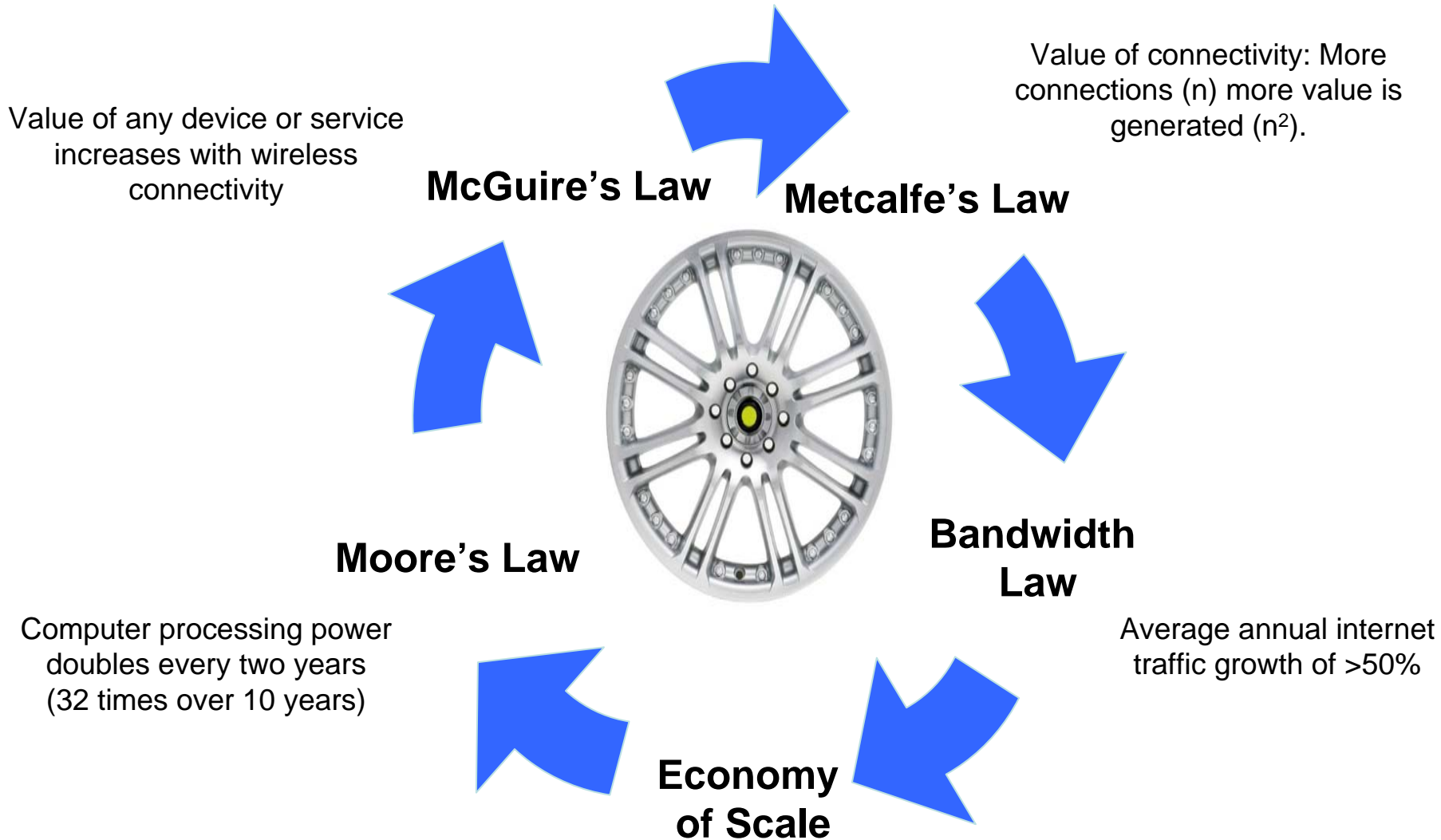
## Spectrum – coping with demand

The question posed is whether technological advances are helping with the increasing demand for spectrum (which is accelerating)

### **Agenda:**

Technology Giveth and Consumer Taketh

# Where (and why) is the Telecom Industry Going: The Forces of Disruption and Innovation



# Technology Advances

(that make the Radio Access Network more efficient)

- Moore's Law
- Inter frequency handoff & devices that handle multiple bands across many technologies
- Higher modulations in cellular networks (QPSK → 16QAM → 64QAM)
- Enhancements in microwave and fiber deployment (and price points)
- Antenna technology improvements
- QoS and bandwidth management per service

What is coming up:

- MIMO (and collaborative MIMO w LTE)
- Multi carrier (in the same and different bands)
- Interference avoidance techniques

# What is MIMO (multiple input / multiple output)?

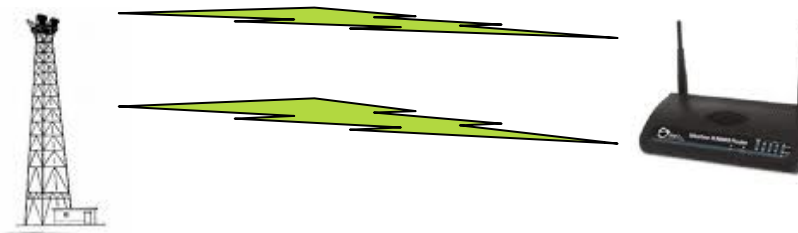
## Today

1 to 1 correspondence  
Between Base station and  
device



## 2x2 MIMO

2 to 2 correspondence  
Between Base station and  
Device. 2 transmitters and 2  
receivers → double the speed  
with the same coverage



## 4x4 MIMO

4 to 4 correspondence  
Between Base station and  
Device. 4 transmitters and 4  
receivers → 4x the speed with  
the same coverage



The result:



# Carrier Aggregation

- 12-14 simulation scenarios were studied in 3GPP for CA feasibility (7 of them shown below)
- **Preferred CA combination proposals being discussed at RAN4 ad hoc**
  - Feasibility study will complete soon - CA work item initiated.
  - It is expected that a few of these CA combinations will be studied in detail (i.e. coexistence simulations) for inclusion in the LTE-Advanced proposal for ITU-Advanced (Completion target = Dec 2010).

Scen. #	Deployment Scenario Description	Trans. BWs of LTE-Adv carriers	Number of LTE-Advanced component carriers	Bands for LTE-Adv carriers	Duplex modes
1	Single-band contiguous spectrum allocation @ 3.5GHz band for FDD	UL: 40 MHz DL: 80 MHz	UL: Contiguous 2x20 MHz CCs DL: Contiguous 4x20 MHz CCs	3.5 GHz band	FDD
2	Single-band contiguous spectrum allocation @ Band 40 for TDD	100 MHz	Contiguous 5x20 MHz CCs	Band 40 (2.3 GHz)	TDD
3	Single-band contiguous spectrum allocation @ 3.5GHz band for TDD	100 MHz	Contiguous 5x20 MHz CCs	3.5 GHz band	TDD
4	Single-band, non-contiguous spectrum allocation @ 3.5GHz band for FDD	UL: 40 MHz DL: 80 MHz	UL: Non-contiguous 20 + 20 MHz CCs DL: Non-contiguous 2x20 + 2x20 MHz CCs	3.5 GHz band	FDD
5	Single-band non-contiguous spectrum allocation @ Band 8 for FDD	UL: 10 MHz DL: 10 MHz	UL/DL: Non-contiguous 5 MHz + 5 MHz CCs	Band 8 (900 MHz)	FDD
6	Single-band non-contiguous spectrum allocation @ Band 38 for TDD	80 MHz	Non-contiguous 2x20 + 2x20 MHz CCs	Band 38 (2.6 GHz)	TDD
7	Multi-band non-contiguous spectrum allocation @ Band 1, 3 and 7 for FDD	UL: 40 MHz DL: 40 MHz	UL/DL: Non-contiguous 10 MHz CC@Band 1 + 10 MHz CC@Band 3 + 20 MHz CC@Band 7	Band 3 (1.8 GHz) Band 1 (2.1 GHz) Band 7 (2.6 GHz)	FDD

## '... and the consumer/technology/market taketh'

(market dynamics and technology limitations that increase the need for spectrum)

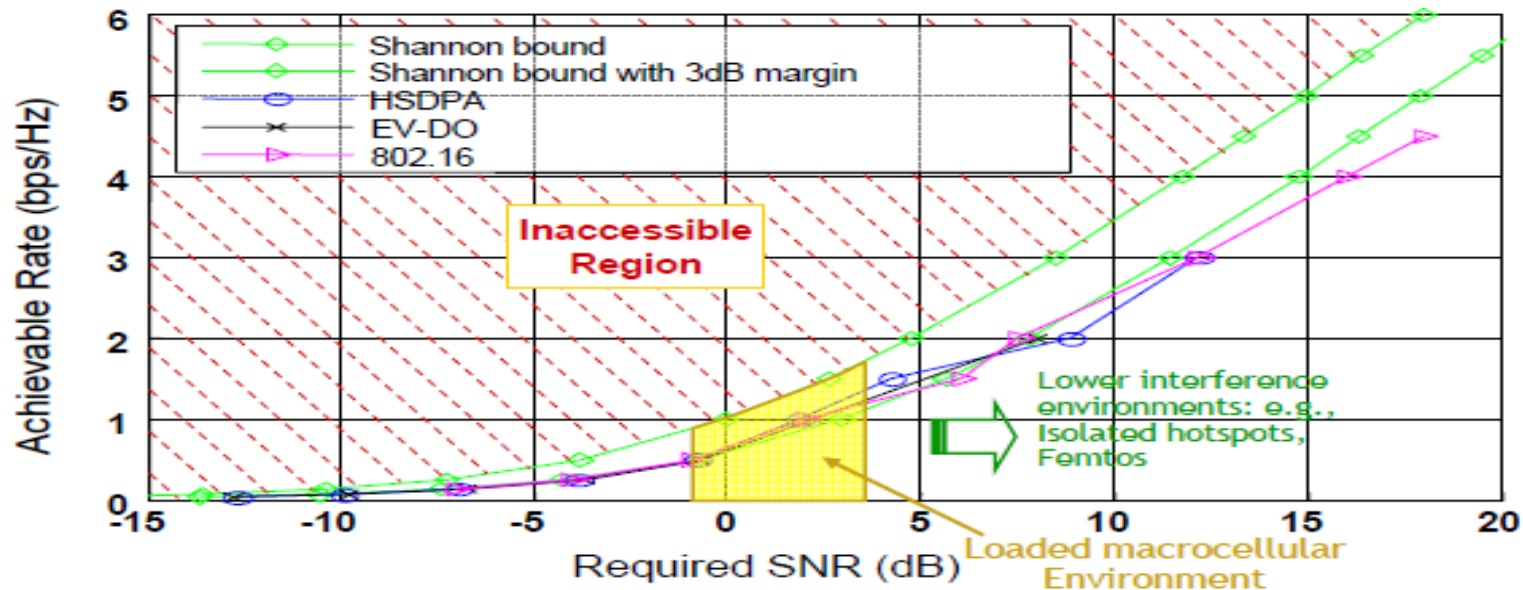
- The more bandwidth available the more users will consume
  - more innovation on applications, higher quality content demanding more bandwidth (fixed broadband is an excellent forecaster of the wireless broadband future)
- Number of subscriptions continues to grow
  - implies need for more spectrum, which need will accelerate with M2M
- Revenue decreases vs traffic and resource consumption
  - necessitates simpler deployments and simpler devices
- Speed of technology change
  - technologies (CDMA, GSM, Wimax, HSPA, LTE...) get introduced at a faster pace but get withdrawn at a slow pace (more spectrum consuming technologies deployed at the same time)

## '... and taketh...'

(market dynamics and technology limitations that increase the need for spectrum)

- Anything, anytime, anywhere
  - porting the fixed experience will require a similar amount of resources
- Interference
  - many coverage layers needed (ex Femto) that need dedicated spectrum
- Wireline replacement / wireless substitution
  - demands for better coverage, more capacity, better resiliency
- Small transactions (vs large data transfers)
  - the hidden consumer of both spectrum and network resources

# Shannon - Link Capacity for Rate-Controlled Technologies

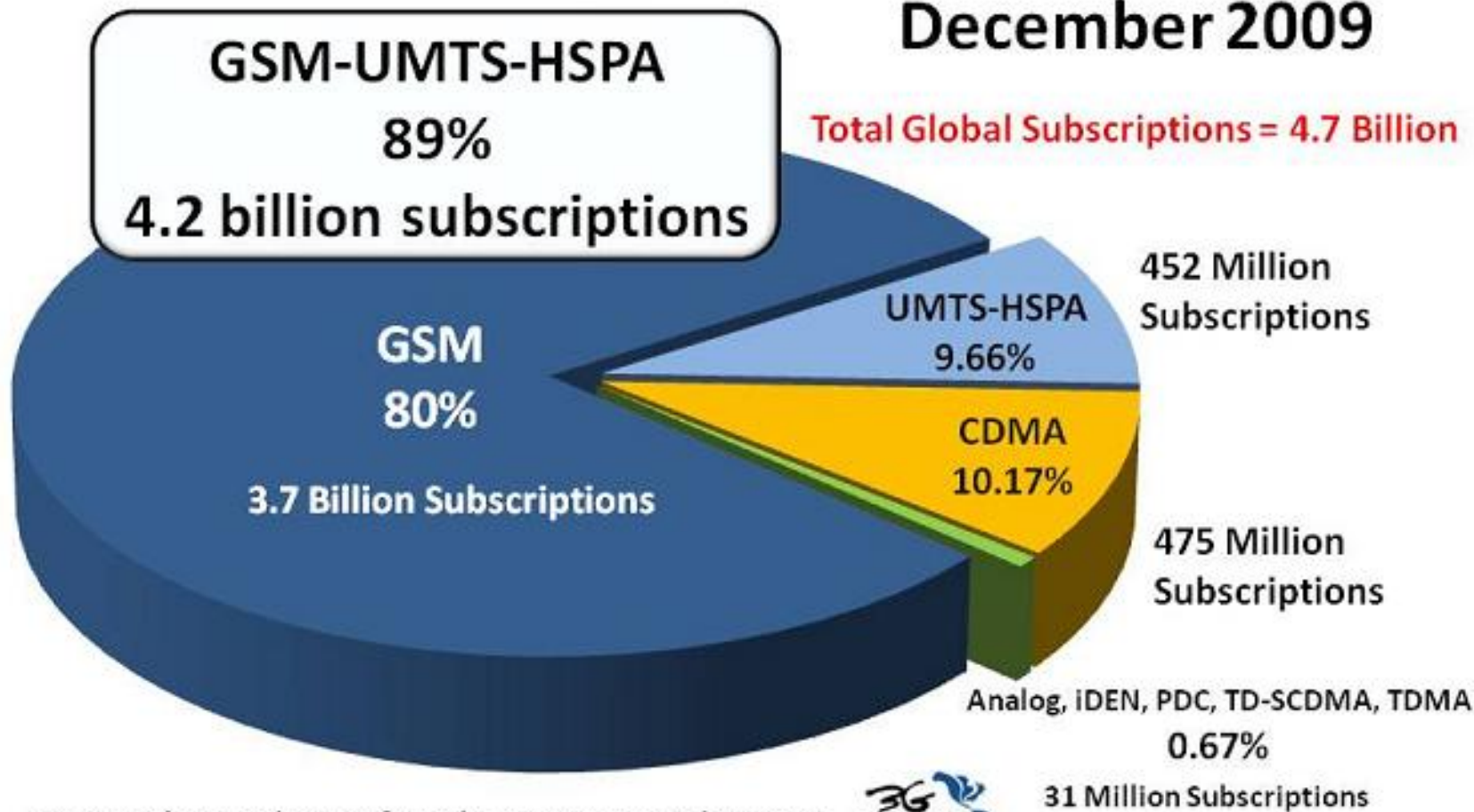


- Current link capacities closely approach the Shannon limit (within ~3dB).
- Future spectral efficiency improvements will focus on interference-reducing IA/SDMA techniques and/or basestation coordination.
- The Shannon–Hartley theorem establishes what that channel capacity is for a finite-bandwidth channel subject to noise.
- If we had an infinite-bandwidth, noise-free analog channel, one could transmit unlimited amounts of error-free data over it per unit of time. Real channels, however, are subject to limitations imposed by both finite bandwidth and nonzero noise.
- The reality is that there is a limit to the amount of information that can be transferred by a signal of a bounded power, even when clever multi-level encoding techniques are used

# Global Subscriptions

## December 2009

Total Global Subscriptions = 4.7 Billion

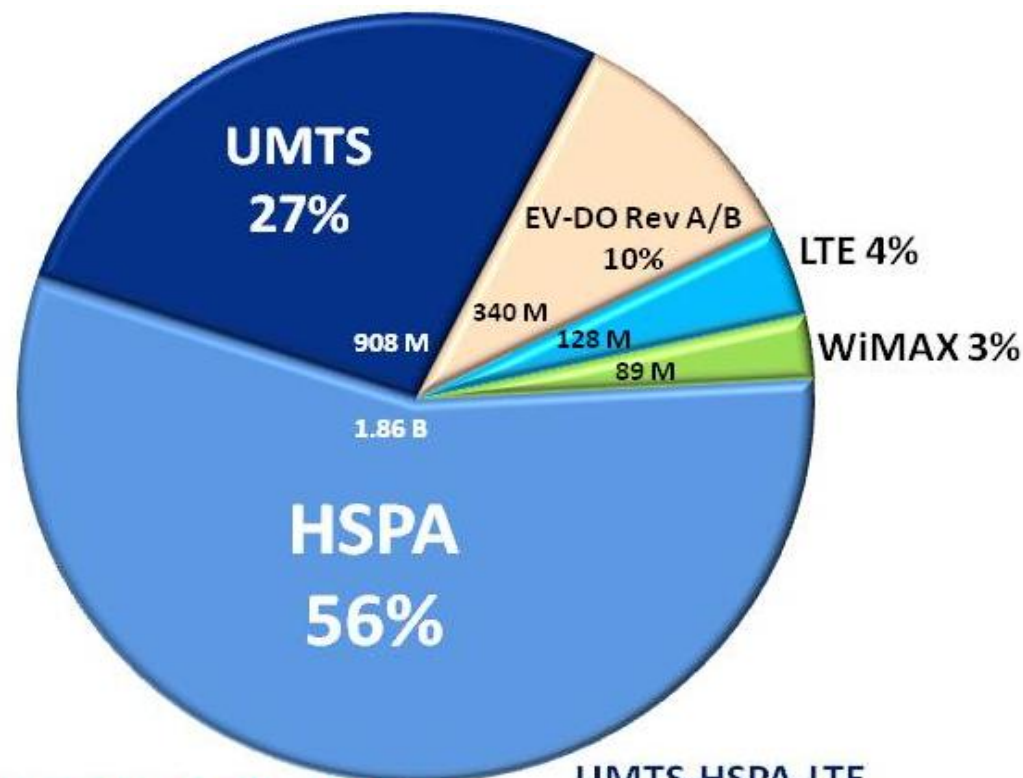


Source: Informa Telecoms & Media, WCIS+, December 2009



[www.3gamericas.org](http://www.3gamericas.org)

# Projected Subscriptions



**3.3 Billion Mobile Broadband**  
Subscribers Estimated by  
Dec 2014

**UMTS-HSPA-LTE**  
**2.9 Billion**  
87% of Global Total

Source: Informa Telecoms & Media, Forecast Summary, 4Q09



# The revenue vs traffic challenge

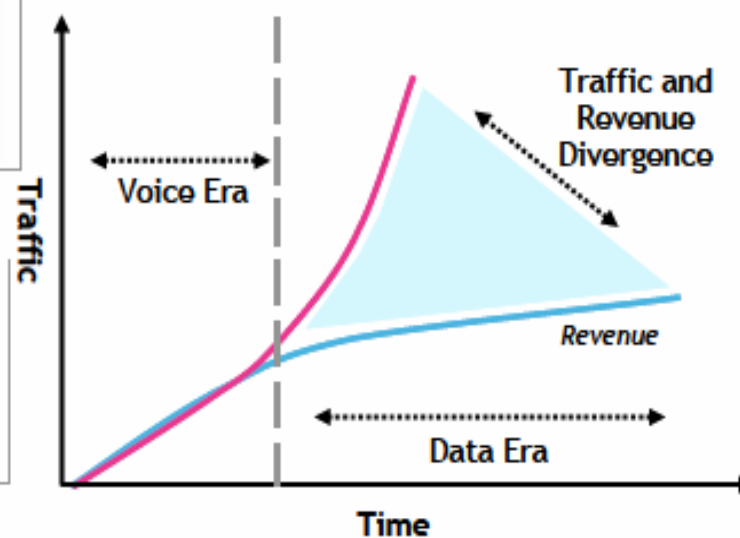
... From 2008 to 2013 ...  
Data Traffic Forecasted: x17 ...

Informa  
(May09)

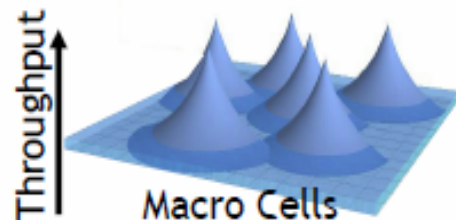
... Data revenues Forecasted: x1.8

Informa  
(May09)

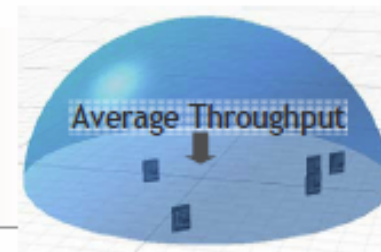
## Telecom Operators Scissor Effect



Heterogeneous  
Radio Quality



Network  
Congestion



# Application Growth

## Mobile data-users growth rate 2008 to 2012

Video	194%	Games	95%
Music	136%	Information service	86%
MMS	99%	E-mail	83%
		Graphics/images	77%
		Ringtones	62%

Source: Pyramid

## New services & devices boost bandwidth usage

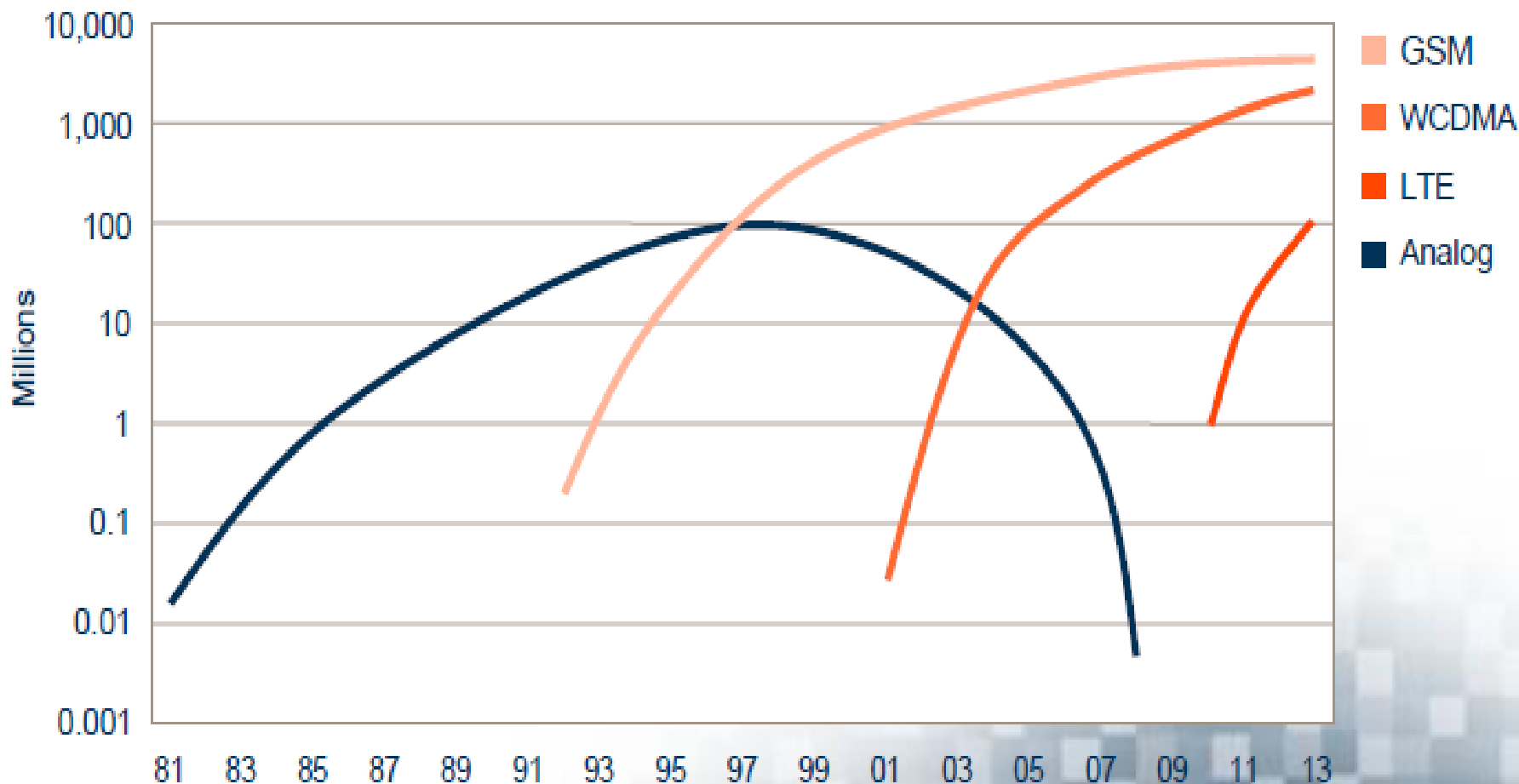
- 5% → 31% streaming video
- 1% → 30% YouTube
- 6% → 58% web search

Source: comScore

# Take up of mobile generations

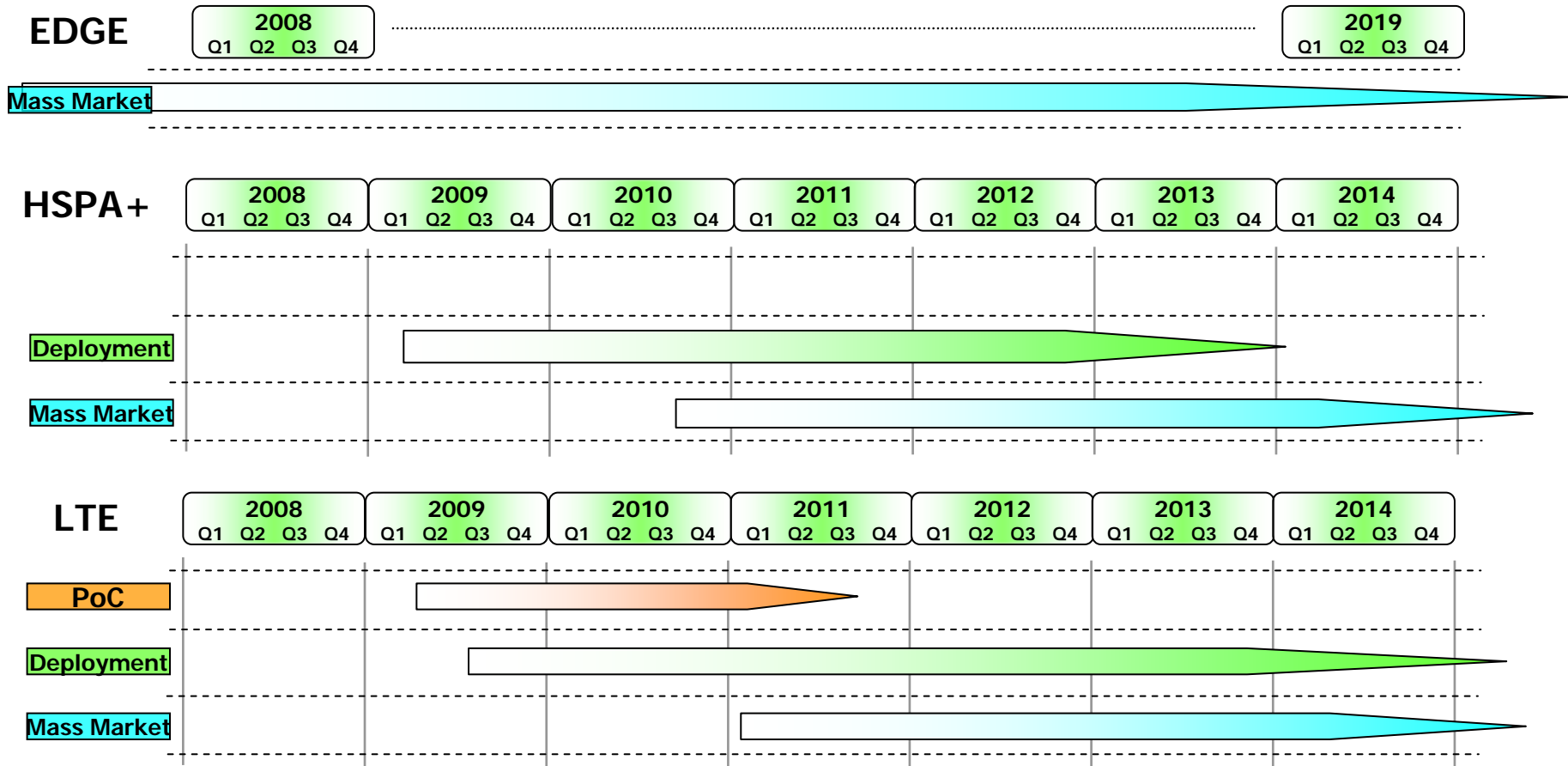
technology introduction is accelerating but not technology removal

Subscription forecast



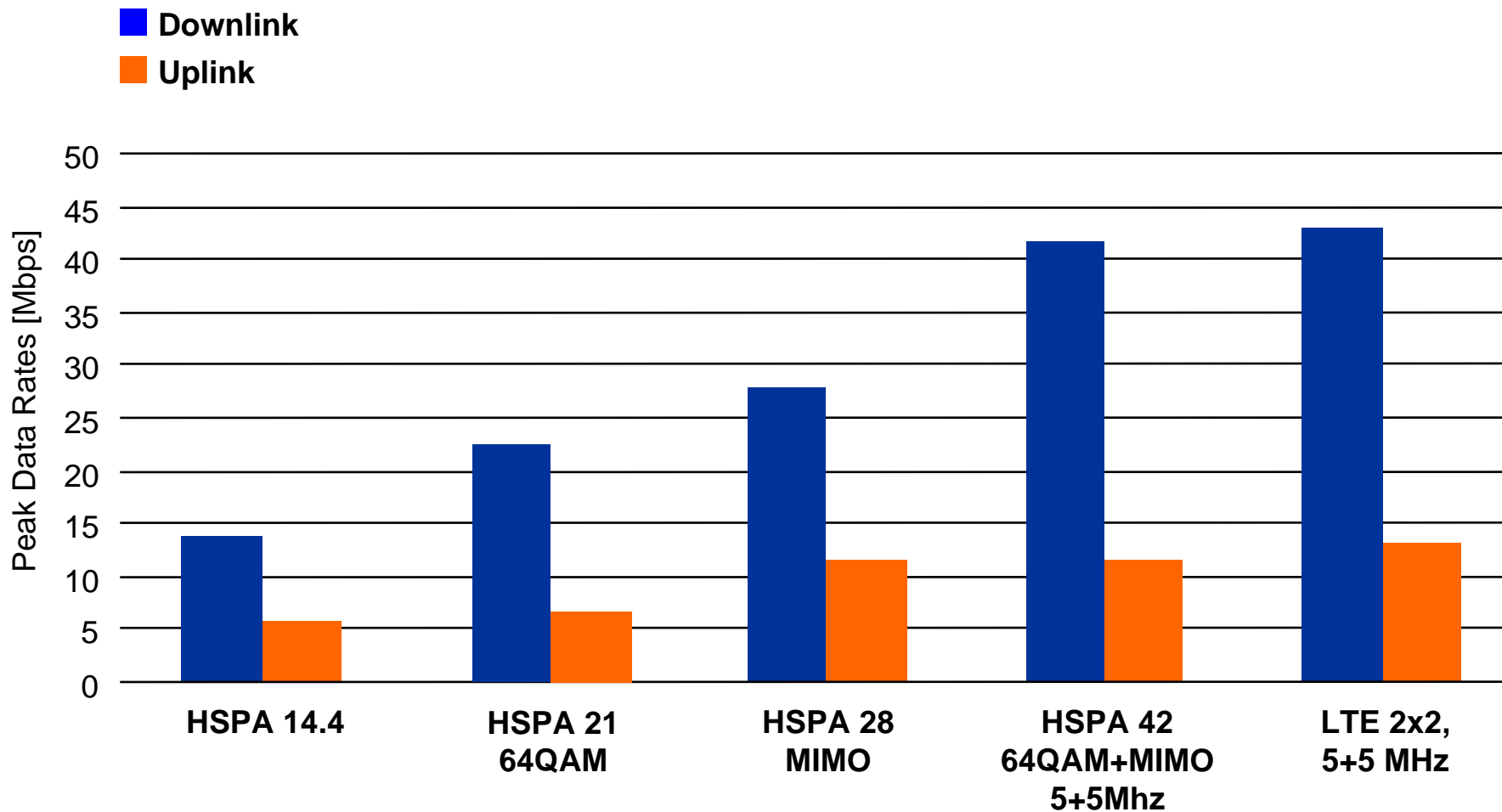
# Lifespan of HSPA+ and LTE (and GSM)

HSPA+ will only become mainstream around 2013-2014



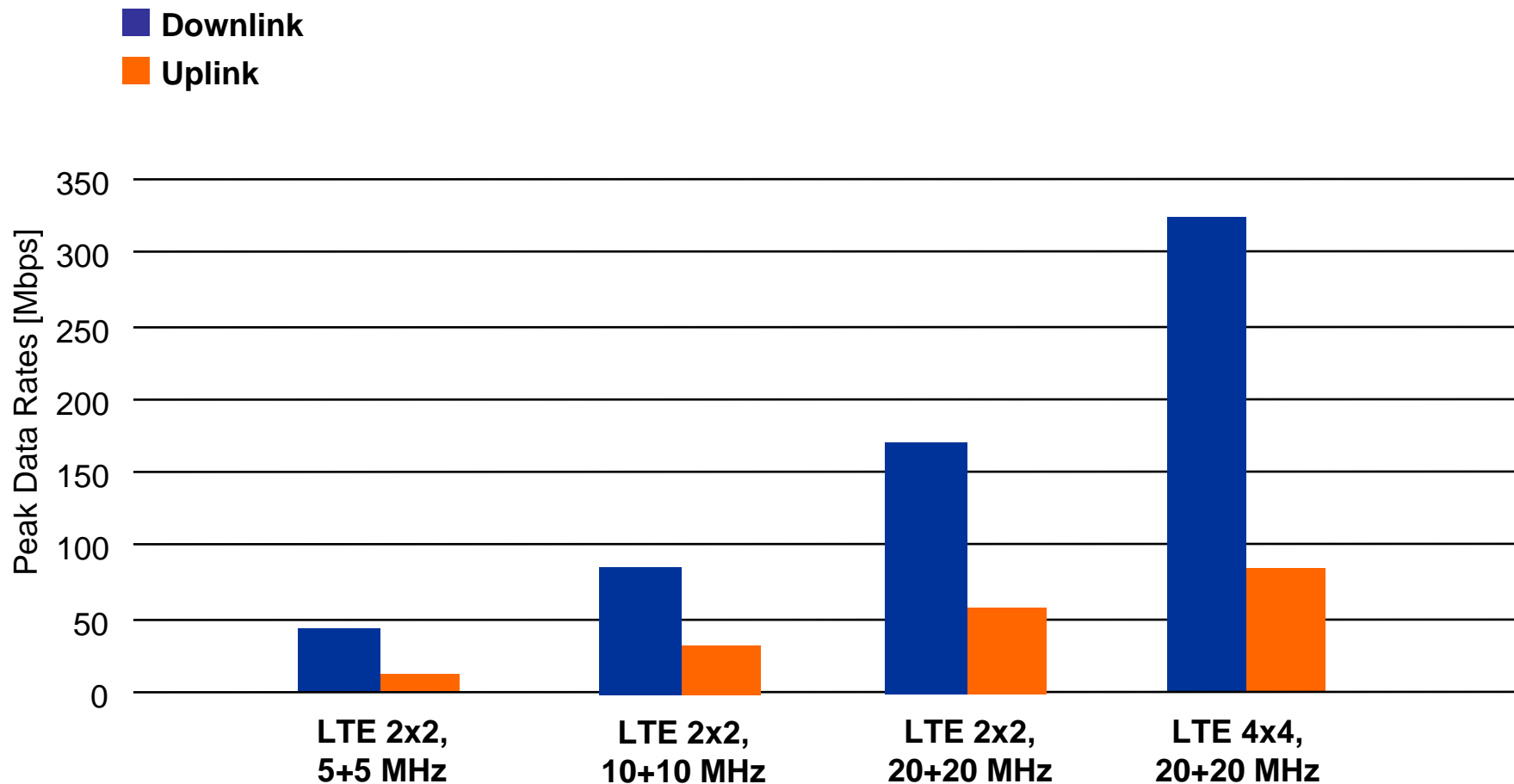
# Peak Data Rates

HSPA and LTE on 5 MHz FDD



# Peak Data Rates

## LTE Standard Capabilities



# Small Transactions?

Small transactions consume a lot of spectrum & network resources

200 users a day, 5 tweets a day = in a month 33.6 Mb

Used the same spectrum and radio resources as a 1Gb download

This implies that M2M (an area of growth) is going to consume a lot more spectrum than the data volume would imply.

## Summary

- Technological advances have and will continue to help with the optimization of spectrum consumption
- These advances are not enough to keep pace with demand and the market thrust towards equating the capabilities of a fixed line user with a wireless one

### **Assuming we all want Canada to be in a leading position globally in wireless innovation and capability:**

- Need to increase spectrum availability
- Spectrum needs to be inexpensive

And, (very important for our Canadian reality)

- The spectrum needs to be globally coordinated and harmonized