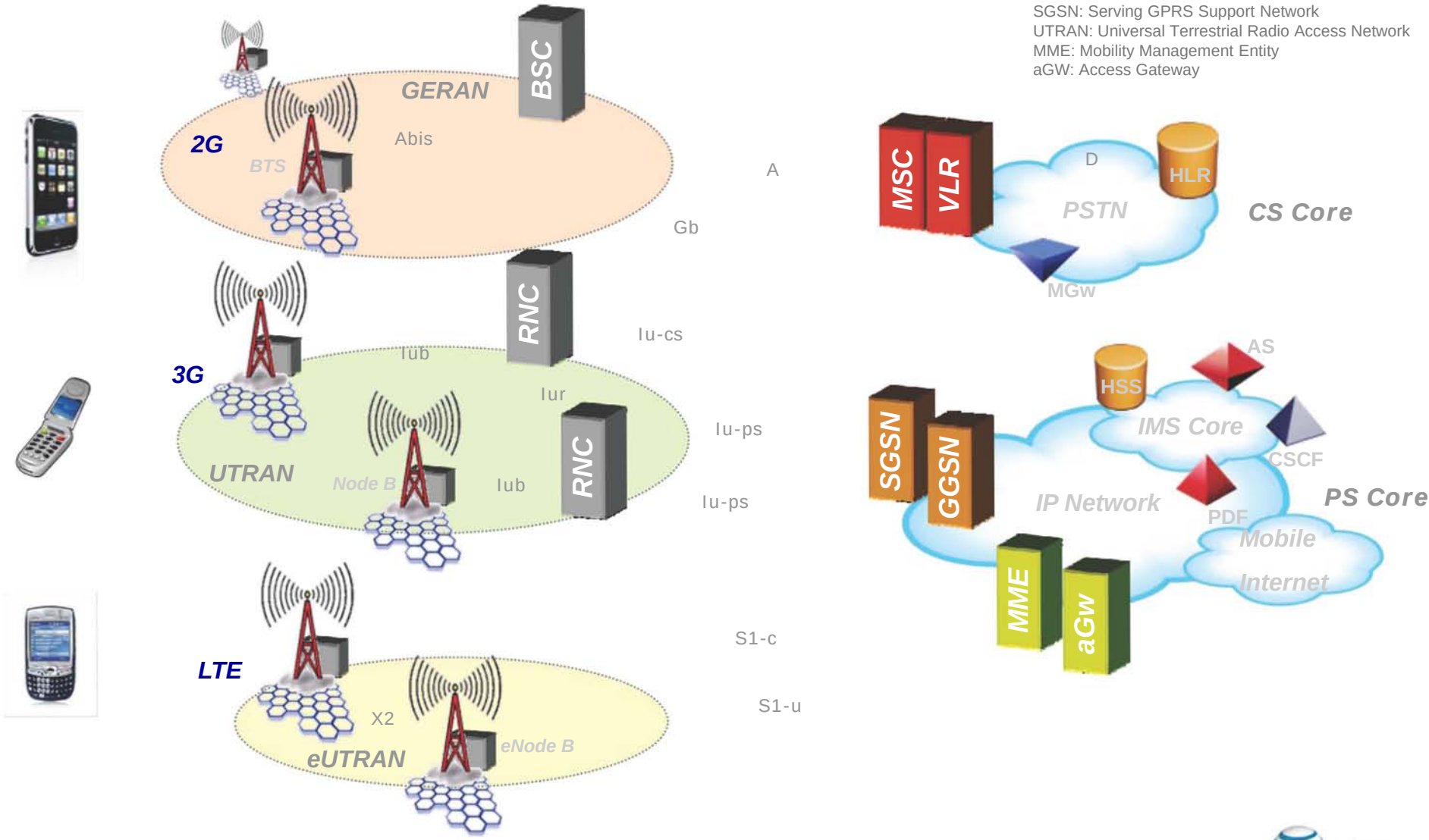
at&t

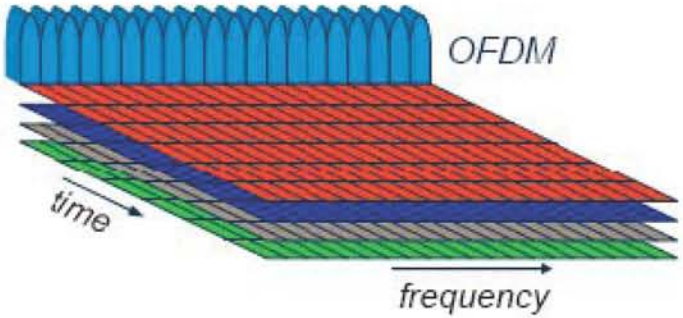
Wireless Network Architecture

BSC: Base Station Controller
BTS: Base Transceiver Station
HLR: Home Location Register
HSS: Home Subscriber Server
GERAN: GSM EDGE Radio Access Network
GGSN: Gateway GPRS Support Network
LTE: Long Term Evolution
MSC: Mobile Switching Center
RNC: Radio network Controller
SGSN: Serving GPRS Support Network
UTRAN: Universal Terrestrial Radio Access Network
MME: Mobility Management Entity
aGW: Access Gateway

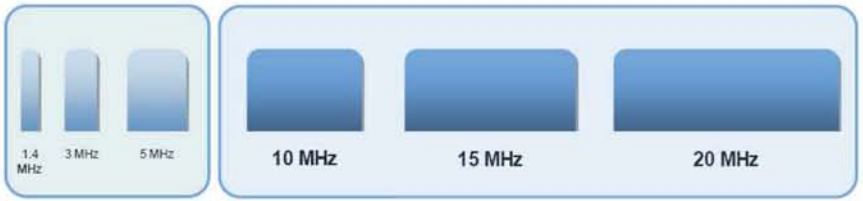


LTE Radio Technology - OFDMA

- Downlink (base to mobile)
  - Based on OFDMA (orthogonal frequency division multiple access)
    - Other systems using OFDM(A) include WiMAX, Wi-Fi, etc.
    - Higher spectral efficiency (more bits/Hz)
  - Data is carried on many narrow "tones"
    - Different tones (ie, frequencies) carry data to different users
    - Takes advantage of fading to send "good" tones to each user
    - Users are scheduled every 1ms



  - Supports channel bandwidths from 1.4 MHz up to 20 MHz
    - UMTS/HSPA uses only 5 MHz
    - Initial LTE focus on 5 MHz and 10 MHz



- Uplink (mobile to base)
  - Called "single carrier" but actually is processed like OFDM
  - More power efficient
    - Better for mobile devices (battery life, etc.)

LTE Advantages

Long Term Evolution offers:	
Higher Data Rates	• Average user throughput: 3-4 times (DL), 2-3 times (UL) HSPA reference • Cell-edge user throughput: 2-3 times (DL & UL) HSPA reference
Low Latency	• User plane: Less than 10 ms (RAN RTT) • Control plane: Less than 100 ms (idle → active)
High Spectral Efficiency	• Three times HSPA R6 baseline • Improved performance for broadcast service
Simplicity	• Less signaling, auto-configuration of eNodeB

Note: LTE speeds are affected by:

- Availability of contiguous blocks of spectrum
- Nearby band interference
- Antenna configuration
- Vehicle motion
- Users in a cell
- Terrain

LTE Data Rates for 10 MHz and 5 MHz Channels

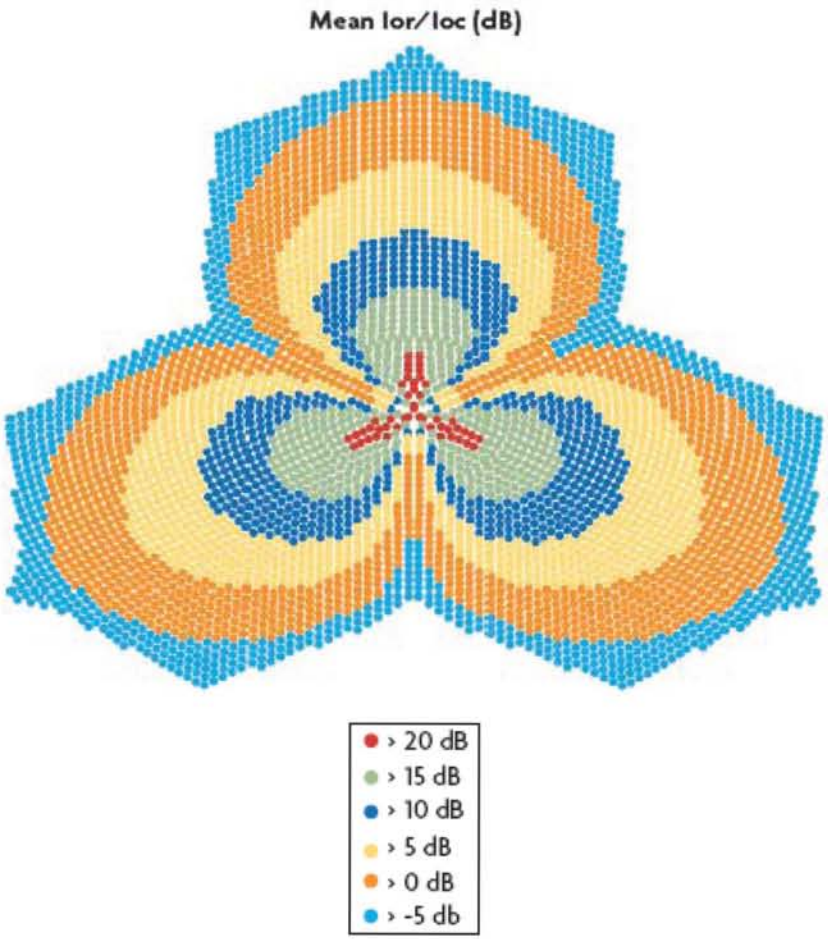
- Peak data rates for single user in best conditions
  - 10 MHz downlink w/ 2x2 MIMO: 73 Mbps
  - 10 MHz uplink w/ 1x2 SIMO: 36 Mbps
  - For 5 MHz channels: DL 37 Mbps, UL 18 Mbps

- Average sector throughput (spectral efficiency)
  - Typically used as a measure of network performance
  - Several users in each sector, loaded network, varying signal conditions
  - Downlink w/ 2x2 MIMO: ~1.5 bps/Hz/sector*
    - 10 MHz channel BW = ~15 Mbps/sector
    - 5 MHz channel BW = ~7.5 Mbps/sector
  - Uplink w/ 1x2 SIMO: ~0.65 bps/Hz/sector*
    - 10 MHz channel BW = ~6.5 Mbps/sector
    - 5 MHz channel BW = ~3.25 Mbps/sector

*From "HSPA to LTE-Advanced: 3GPP Broadband Evolution to LTE-Advanced (4G)", Rysavy Research for 3G Americas, Sept. 2009, www.3Gamericas.org

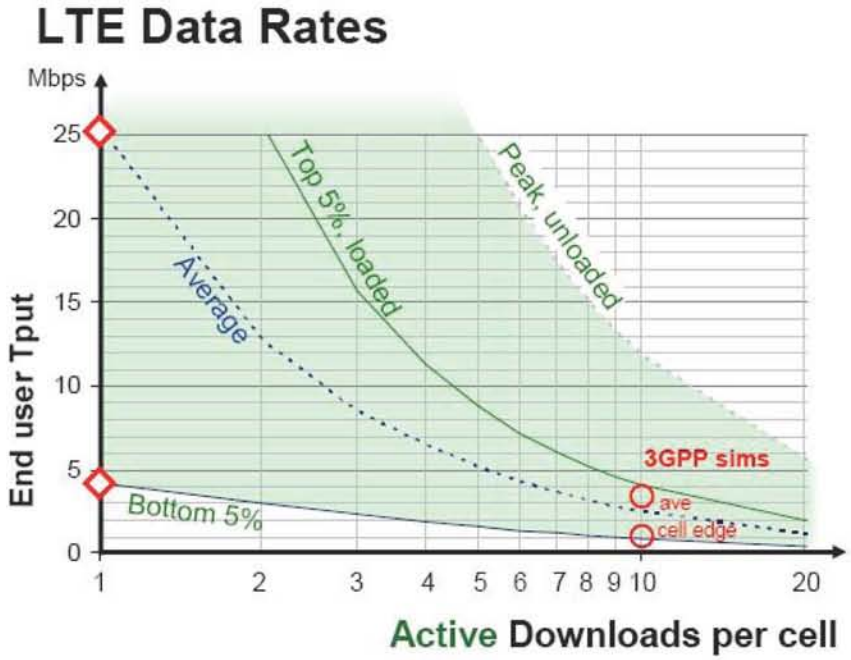
Signal Levels and SINR Distribution

- Signal levels vary across the sector due to radio propagation loss, shadowing, building penetration, etc.
- Signal to Interference+Noise Ratio (SINR) also varies due to desired signal level and interference from other sectors (cells)
- Data throughput speeds vary as the SINR varies



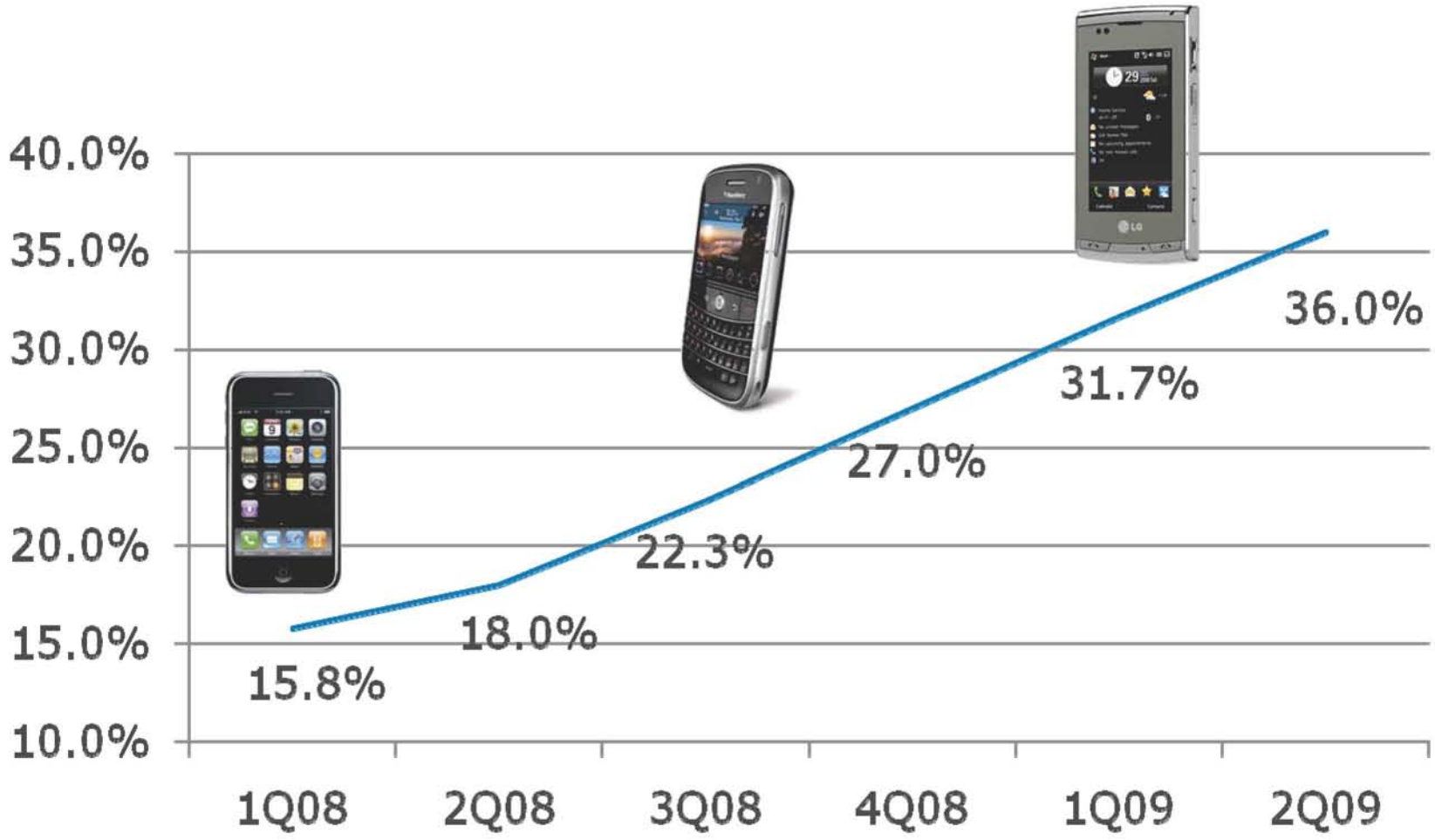
Multiple Users per Sector

- Available throughput is shared between the *active* devices in the sector
- Results from lab measurements for 20 MHz bandwidth channel
  - For 10 MHz channel, rates would be 50% of shown
  - For 5 MHz channel, rates would be 25% of shown



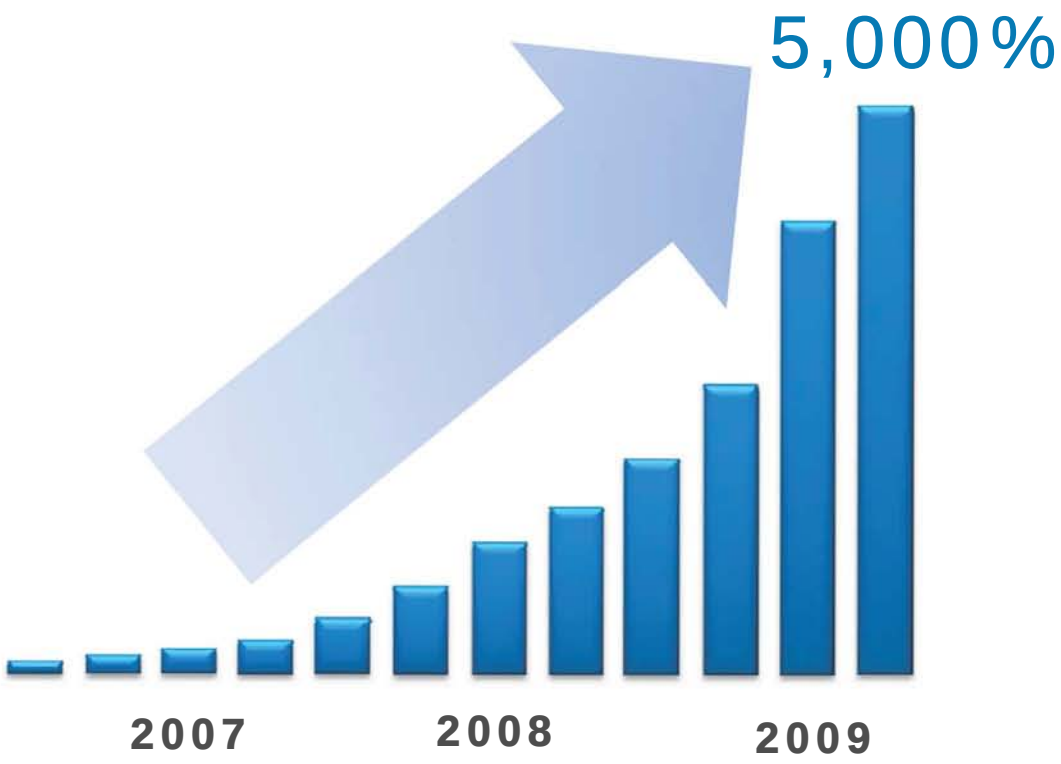
- From "Update from the LTE/SAE Trial Initiative", Oct. 2009, www.lstiforum.org

Growth of Smart Devices (postpaid subscribers)



Wireless Data Growth Skyrocketing

AT&T Data Traffic Growth
2Q06-2Q09



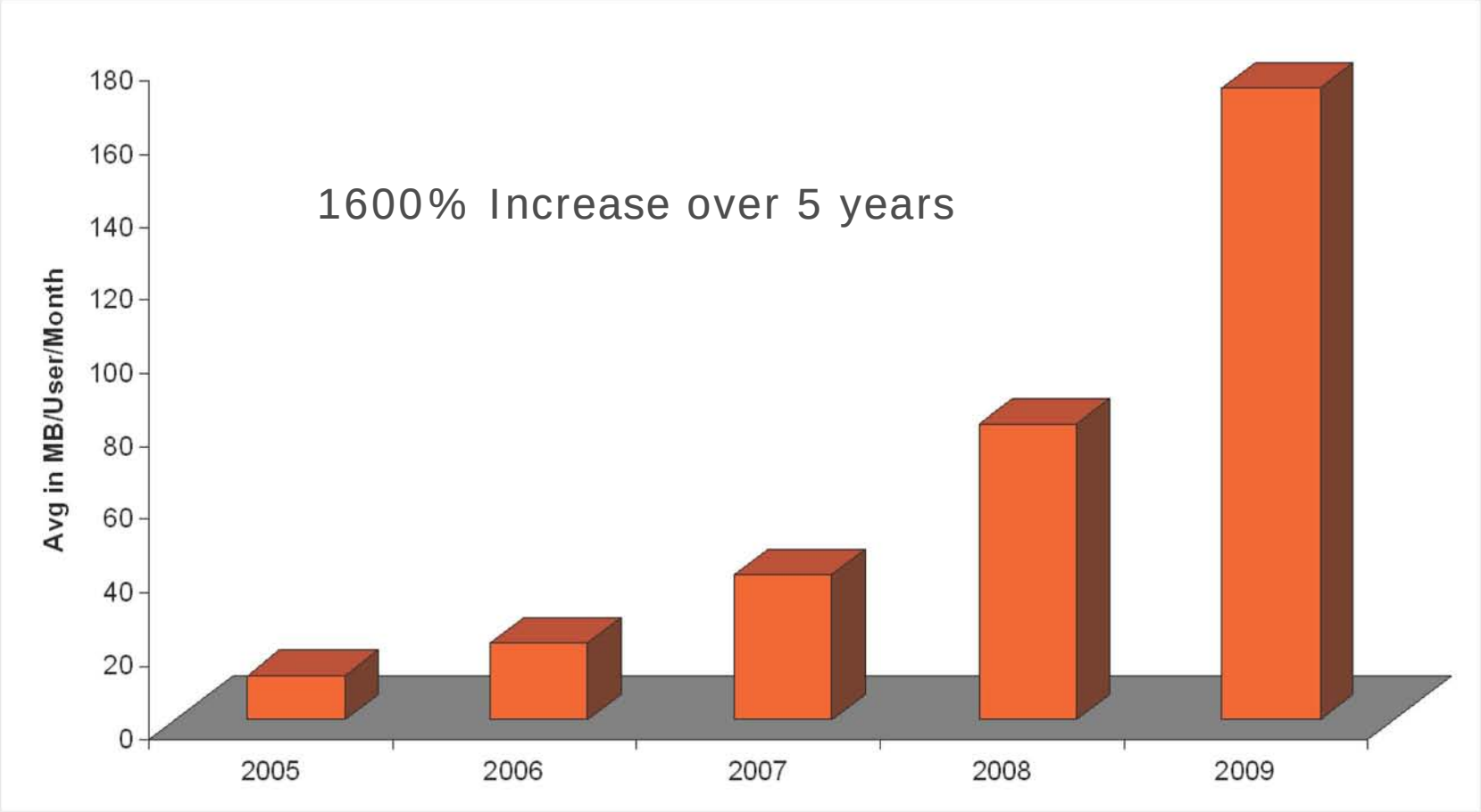
AT&T data up 4,932% last 3 years

Disproportionate use by a few

Top 3% of smartphone customers:

- Use 40% of all smartphone data
- Consume 13x the data of the average smartphone customer
- Represent only .9% of AT&T's total postpaid customer base

Monthly Data Usage – Government Segment



700 MHz Public Safety Spectrum

- Current allocation for broadband public safety spectrum consists of two 5 MHz paired blocks (2x 5+5 MHz)
  - Could deploy 5 MHz LTE radio in PSBB spectrum and another 5 MHz LTE radio in D Block
  - Better solution is for PS to deploy a 10 MHz LTE radio on the available spectrum
- The 10+10 MHz allocation can be described as **beachfront property** in terms of spectrum availability and the available channel bandwidth
- Advantages:
  - Approx. the same cost for 10+10 MHz LTE compared to 5+5 MHz LTE
  - Allows higher peak data rates and higher overall network throughput
  - This is the best **"bang for the buck"** for Public Safety and will provide true broadband and multimedia capability with future growth
  - While there are incremental technology advances that will improve the overall spectral efficiency, these will not provide the increases needed to meet the demands for mobile, broadband, multimedia services