4G + Data Caps = Magic Beans

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A special note to all the unpaid family tech support specialists out there ...

For years you have been giving advice to your family about what technology to buy and what technology to skip. You have told them that when they are buying a laptop it is worth paying for extra RAM, but that the base hard drive will be fine for holding their holiday photos. You have told them that the five dollar HDMI cable is just as good as the 100 dollar one. You have told them that more megapixels does not always mean a better camera.

Pretty soon, you are going to get a new question from your family: "should I upgrade to 4G?"

In almost all cases, your answer should be "no."

This is not because 4G itself is fatally flawed. 4G wireless technology has an incredible amount of potential. It can transfer data much faster than existing 3G connections. It makes more efficient use of spectrum. It is a performance upgrade by almost any metric.

Your answer should be no because 4G comes with a huge caveat on the country's two largest carriers: data caps. These data caps limit the amount of usage your relative is going to get out of the 4G network. Simply put, data caps make the advantages of 4G irrelevant. The caps prevent anyone from making habitual use of the full potential of a 4G network.

Introduction[1]

Wireless carriers are bombarding consumers with ads touting new 4G wireless technology. They say that 4G, the next generation of wireless data technology, promises higher speeds and better wireless internet experiences. Today some of the uses for 4G are clear, like video and gaming. Other uses will only manifest themselves after widespread adoption. However, unlike past speed increases, for most users the 4G offered by major wireless carriers is a waste of money.

That is not because 4G itself is fatally flawed. 4G can transfer data much faster than existing 3G connections. It makes more efficient use of spectrum. It is a performance upgrade by almost any metric.

The 4G offered by major wireless carriers (with the notable exception of Sprint) is a waste of money because it comes with strict data caps. These data caps actively discourage the types of activities that 4G enables. Activities that are made possible by 4G, such as watching movies or uploading video to the internet, are made impossible by the data caps. As a result most users will avoid taking advantage of these new services out of fear of incurring large overage fees. That makes capped 4G little more than a bait and switch, like being sold a handful of magic beans.

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Before getting down to business, it is worth mentioning that the term "4G" comes with its own set of controversies. Although it once enjoyed a specific, technical meaning, as of this writing 4G has largely been co-opted by the marketing departments of wireless carriers. Today, 4G can refer to an assortment of technologies such as HSPA+ and LTE. However, this patchwork is largely invisible to the public. While it is very likely that your cousin will call to ask about 4G, it is less likely that they will wonder about the relative merits of bonded HSPA+ networks versus WiMax versus LTE. In light of this, this paper will take carriers at their word and simply accept that 4G means whatever individual carriers say it means.

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[1] Thanks to Meredith Filak, Joe Newman, and especially Peter Brody for their research in support of this paper.

4G is Amazing

Nothing in this paper should be read to question the advantages of 4G wireless technology, or of faster, more efficient networks in general. The various 4G technologies have enormous potential to improve wireless connectivity and fundamentally change the way that individuals on the move connect to the digital world.

Some 4G technologies can support streaming true high definition video and two-way video calling. Combining these fast wireless "pipes" with emerging streaming technology could allow users to play data-intensive video games on the go. Perhaps more importantly, combining mobility with high capacity data networks promises to spur the creation of entirely new types of applications and services that are hard to imagine today.

4G also has advantages that are less obvious to a standard user. 4G radios can make more efficient use of spectrum than older wireless technologies, allowing more connections to exist simultaneously in a single space. Although the full benefit of this efficiency will only be realized once carriers complete the transition to 4G, in the long term it could greatly reduce some types of network congestion.

And this is why this paper is not titled simply "4G = Magic Beans." Faster broadband connections are always better, often for reasons that are hard to articulate at the time. Once people had a broadband connection that was fast enough to download emails and load pictures close to instantly, many of them assumed they had a "fast enough" connection and could not imagine what they would do with more speed. But once YouTube, Netflix, and Hulu came around, people were happy the network had continued improving.

However, for reasons detailed below, attaching low data caps to fast connections undermines most of the benefits offered by those fast connections. The 4G caps essentially freeze the usefulness of wireless networks at the 3G level even as theoretical speeds increase.

Capped 4G is a Sucker Bet

The imposition of data caps on 4G networks marks an unfortunate milestone in the history of network innovation. For the perhaps first time, the introduction of a generationally faster technology will not have a widespread impact on online behavior. As long as there are low data caps, most users will be better off staying with a (cheaper and slower) 3G connection than paying a premium for 4G.

The Caps

This paper will focus on the caps imposed by the two largest wireless carriers, AT&T and Verizon.[2] These caps are substantially similar in structure and, as the largest industry players, together AT&T and Verizon often set trends for the industry.

The 4G data plans have tiers. The lowest tier could only be useful for the lightest of email and web browsing, and would effectively prevent a user from using any application that would justify moving from a 3G to a 4G network. On AT&T, this tier is $15 for 200 MB of data.[3] Verizon's lowest tier is $10 for 75 MB and is limited to non-smart "feature" phones.

The next tier is likely to be the most popular, and is targeted at average users.[4] As such, it is the tier that will be used for analysis in this paper. The data cap on this tier is 2 GB on both AT&T and Verizon, although AT&T charges $25 and Verizon charges $30. Both charge $10 per each GB over the cap.

AT&T and Verizon also offer higher tiers for power users. AT&T offers a $45/4 GB plan, and Verizon offers both a $50/5 GB and a $80/10 GB plan. All charge an additional $10/GB if users exceed their cap. As these plans will likely be most

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[2] T-Mobile also has data caps on its 4G network. Unlike AT&T and Verizon, when a T-Mobile customer exceeds the data cap the customer is not charged overage fees. Instead, the customer's traffic is slowed until the end of the billing cycle. This provides a slightly different set of incentives than the overage fee system used by AT&T and Verizon, which is why it is excluded from this paper. However, it still generally encourages users to avoid the types of data-intensive activities that 4G theoretically enables. Furthermore, if AT&T successfully merges with T-Mobile, the distinction will cease to exist. Sprint is currently the only major carrier to offer a truly unlimited data plan to customers.

[3] Data caps are calculated based on the total volume of data uploaded and downloaded by a user in a given month.

[4] $30 is what both AT&T and Verizon have charged for unlimited 3G data in the past.

appealing to users with specific wireless data needs and significant financial resources, they are not considered in this analysis.

Impact of the Caps

Data caps do not prevent occasional use; instead, they inhibit casual and habitual use. Furthermore, they create a disincentive for network use on any specific occasion.

As detailed below, a 2 GB cap does not completely eliminate the usefulness of having a wireless data connection. It is possible to download emails or browse the internet without hitting the limit. However, it is hard to do the types of activities that 4G is advertised as enabling without quickly flirting with the caps.
Data caps are calculated on a monthly basis. If a user decides to watch a movie or upload a video, she needs to decide if it is going to be the one movie or video that she uploads or downloads that month. Users will need to come to terms with the fact that their movie today may prevent them from accessing their email next week.

This pressure is exacerbated by the fact that the types of services that are best enabled by 4G are the same services that drive up data use the fastest. Email, maps, and light internet browsing work well over today's 3G connections. These activities may not really need a 4G connection and are unlikely to use up 2 GB of data in a month. HD video and uploading large files, on the other hand, benefit greatly from 4G speeds. They also can use up data caps in minutes.

Looking at the Numbers

The observation that data caps will reduce the usage of the capped networks is, in and of itself, an uninteresting one. The relevant point is that this reduction is so limiting it undermines the need for access to the capped network in the first place. In order to illustrate this point, this section will show how quickly various activities will run afoul of the cap.

Two Caps

The following graphs show two different caps – one at 2 GB and one at 1.5 GB. The 2 GB cap reflects the entirety of the cap offered by AT&T and Verizon. The 1.5 GB cap can be thought of as a rough approximation of the "4G surplus."

Currently, Android and iPhone users consume an average of approximately .5 GB of data per month.[5] Although BlackBerry and Windows users consume somewhat less data, the app-rich Android and iPhone platforms provide the best approximation of a profile of a user making full use of her 3G phone. These users rely on their phones to access email, webpages, stream short web videos, and download apps. By and large, these uses and applications work on 3G networks today. When they perform sub-optimally, it is more often than not a function of a shortage of network capacity than an inherent limitation of 3G technology.

This .5 GB can be thought of as a baseline of consumption that is not significantly improved by a switch from 3G to 4G. It is also the amount that a user would need to reserve from the allocated cap to ensure basic functionality of her phone for the month. That leaves 1.5 GB for experimentation and use of new 4G applications.

[5] Don Kellogg, *Average U.S. Smartphone Data Usage Up 89% as Cost Per MB Goes Down 46%*, nielsenwire (June 17, 2011) *available at* http://blog.nielsen.com/nielsenwire/?p=28035.

Examples of Limits

To put current wireless data caps in perspective, it can be helpful to compare them to past data caps. In 2008 Comcast offered its wired cable internet customers standard tiers with 6 Mbps and 8 Mbps download speeds – speeds roughly comparable to today's advertised wireless 4G download speeds.[6] At that time, Comcast imposed a 250 GB cap on users[7] – 125 times larger than today's 2 GB cap.

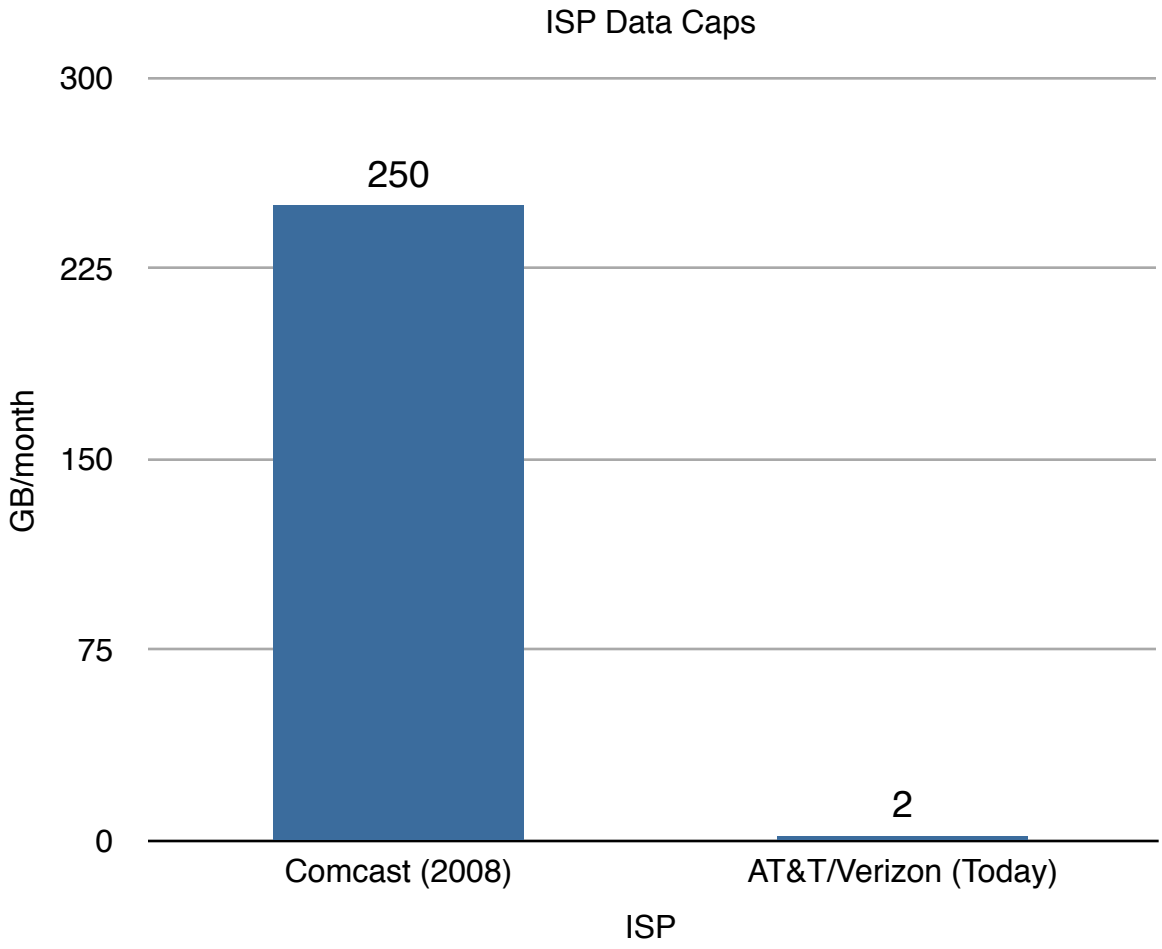

Chart 1

[6] *Comcast Begins Rollout of Extreme 50 Mbps High-Speed Internet Service*, Comcast Corporation (Oct. 22, 2008) *available at* http://www.comcast.com/About/PressRelease/PressReleaseDetail.ashx?PRID=814.

[7] *Announcement Regarding An Amendment to Our Acceptable Use Policy*, Comcast Corporation (2008) *available at* http://xfinity.comcast.net/terms/network/amendment/.

Before discussing specific applications, it is worthwhile to consider the result of the straightforward combination of high 4G speeds and low 4G data caps. Chart 2 illustrates that continuous usage of either the AT&T or Verizon network at top advertised speeds would use up a month's worth of data allotment in less than one hour.

AT&T advertises its 4G network as being capable of download speeds of "up to approximately 6 Mbps."[8] Verizon advertises top download speeds of between 5 Mbps and 12 Mbps.[9] As with the definition of what constitutes 4G, this paper defers to the carriers and assumes that their networks will actually deliver these speeds.

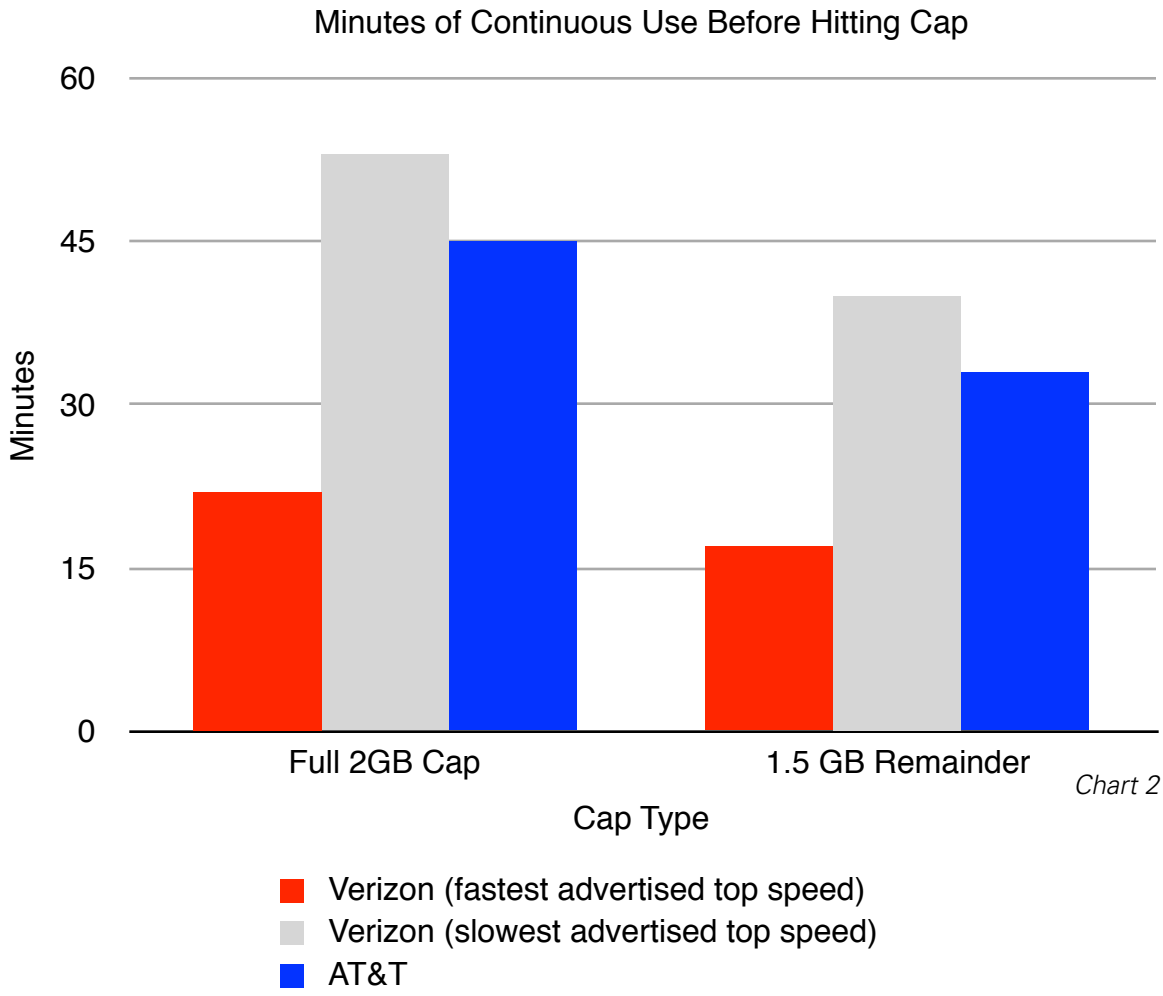

Chart 2

[8] *See Just How Fast is AT&T 4G?*, AT&T, *available at* http://www.att.com/esupport/article.jsp?sid=KB115947#fbid=gFl2qtBBQCV

[9] *See What is 4G?* Verizon, *available at* http://network4g.verizonwireless.com/#/whatis4g.

Obviously, it would be hard – if not impossible – to sustain continuous top network transfer rates in order to reach the cap in under 25 minutes. However, Chart 2 does illustrate the problems associated with combining low data caps with high data speeds.

A more real-world use of the 4G network would be to download media on the go. Video is widely promoted in conjunction with 4G networks, and rightly so. High definition video is exactly the type of data-intensive application that would benefit from a faster network.

Unfortunately, caps make downloading HD movies a non-starter on AT&T and Verizon's 4G network. Chart 3 shows how users would hit their caps well before completing the download of a single HD movie from iTunes over the 4G network.

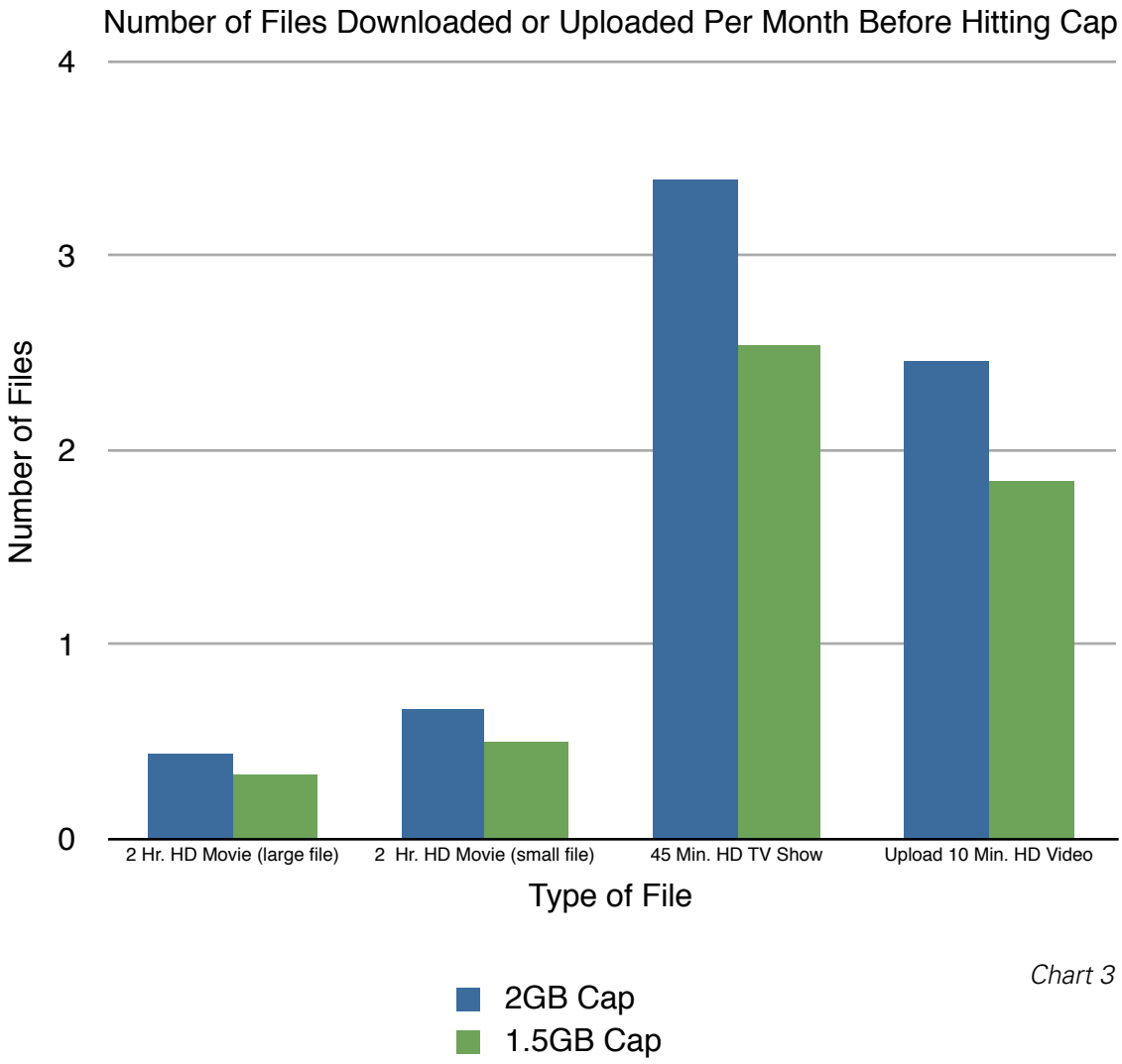

Chart 3

Users in search of HD television fare a bit better. Two 45-minute HD television shows fit under the cap.[10] If the user does not anticipate using very much of the rest of their cap that month, he may be able to download a third. Of course, as noted earlier, this cap is for the entire month. Before downloading a show, the user must be fairly certain that he will not want to download a show later in the month, or use his data for other purposes. This discourages habitual downloading over the 4G network.

In addition to downloading video, users of 4G networks may be interested in uploading their own videos. Most 4G-capable smartphones are capable of recording HD video. Under a 2 GB cap, that activity is limited as well. A user would only be able to upload a maximum of two 10-minute HD videos per month.[11]

There are alternatives to downloading full video files over the 4G network. Media consumption is increasingly shifting away from pure downloading and towards on-demand streaming. It will likely come as no surprise that data caps limit streaming as well.[12]

Perhaps the most well-known video streaming service is Netflix. Netflix offers a number of movies and TV shows available for streaming to customers, and it would be tempting to use a 4G network to access that content on the go. Under a 2 GB cap, users would be able to watch about three hours of content per month, assuming they did not also want to use their data connection for other activities.

Accessing other live streaming media over a capped 4G network may only be a slightly better experience. Video currently optimized for an iPhone would hit the cap in approximately seven hours, and video currently optimized for the iPad would last closer to three or four. As 4G screens grow and improve it is likely that streaming video quality will increase as well, thus driving more content towards the iPad standard.

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[10] One hour television shows traditionally contain approximately 45 minutes of content, with the remainder devoted to interstitial commercials.

[11] Differences in compression technology account for the differences between a 10-minute video taken on a phone and a 45-minute television show downloaded from iTunes. Generally speaking, the television show's compression would be optimized for a smaller screen, while the video taken by the phone would retain enough data to display full resolution on larger screens.

[12] Calculating average data consumption of streaming services is necessarily imprecise, rendering the following calculations estimations. See appendix for a description of the sources for these calculations.

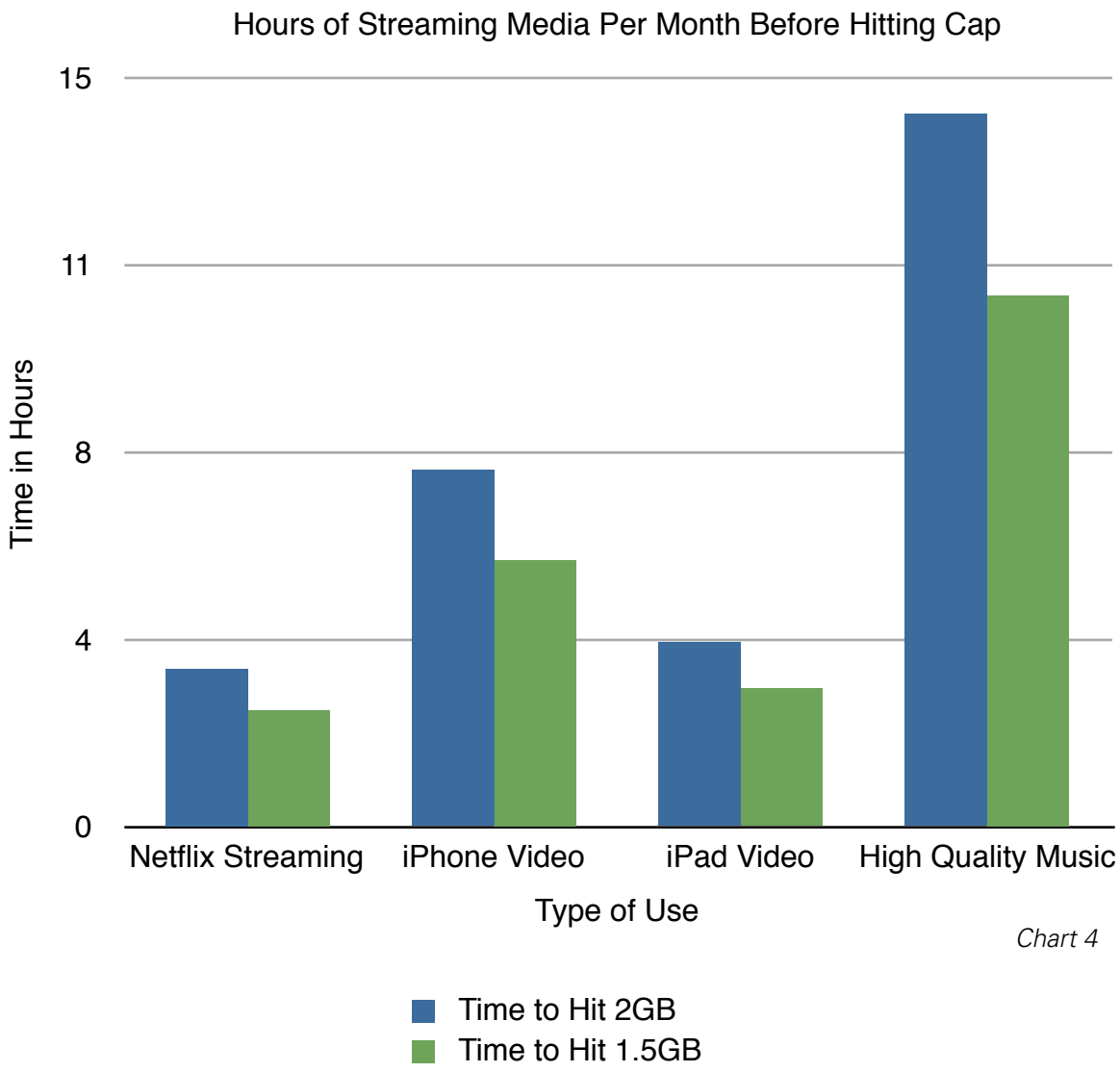

Chart 4

Streaming content is not limited to video. Many services offer high quality music streaming to customers. Because music usage patterns differ from video usage patterns, users who stream music are likely to be just as frustrated as video consumers. While accessing a movie a few times a month might be adequate for some users, people like to be able to listen to music for hours a day. AT&T and Verizon customers will be able to stream a total of approximately 14 hours of music before hitting their 2 GB cap, and a total of 11 hours before hitting 1.5 GB. Over the course of a 30-day month, this is significantly less than 30 minutes of music a day. Again, that is enough to dabble, but not enough to use habitually without paying overage fees.

Two Additional Considerations

First, all of these charts are artificial, in the sense that most users will not just download a movie or stream a little music or upload a video or two. Instead they will do (or aspire to do) a combination of those activities, along with checking email, getting directions, and looking up restaurant reviews. In many ways, this mix makes it even harder to use a capped 4G network. Keeping track of the number of minutes of video you have streamed to one device in a month is a relatively straightforward process. It is significantly more difficult to track data usage across video streaming, music streaming, file downloads, file uploads, and countless other activities. As they will never really know what they will need to do for the rest of the month, most users' inclination will be to hoard that capacity whenever possible – meaning they will avoid the very applications that made 4G attractive in the first place.

Second, this paper would be incomplete without making some mention of WiFi. Almost all 4G devices will have WiFi capability that allow users to offload data from the 4G network onto local networks in order to avoid the caps. However, this paper ignores WiFi for a reason. If the response to problems with 4G data caps is to tell people to use WiFi, then there is no compelling reason to tell people to pay for 4G in the first place.

Conclusion

The family of technologies that make up 4G are impressive and highly capable. 4G networks have the capacity to allow users to do things that were once impossible and support the creation of currently unanticipated types of uses.

Arbitrary data caps mitigate almost all of those advantages. They create a disincentive to use the types of applications that benefit the most from 4G speeds. For most users, money spent to access a capped 4G network is money wasted.

These data caps were not created in a void. They are a direct result of increasing consolidation and decreased competition in the wireless industry. In the 1990s, dial-up internet access was originally billed on a per-minute or per-hour basis. Over time, competition between thousands of dial-up ISPs drove down that per-hour cost and eventually resulted in low cost unlimited access. ISPs knew they had to offer affordable unlimited access because that was what consumers wanted, and consumers could easily switch to another ISP if their current ISP was not interested in offering an unlimited option.

That is simply not the case in the wireless world. There are four true nationwide wireless carriers, with two of those (AT&T and Verizon) looming especially large over the market. Customers are locked into muti-year agreements and are generally unable to switch their phones between carriers. This lock-in effect, coupled with very limited options, has been disastrous for competition. The market is increasingly structured in ways that benefit the handful of wireless carriers to the detriment of the multitude of consumers.

As a result, we are stuck with the magic beans of capped 4G wireless networks. They promise unlimited possibilities. However, they will deliver little except anxiety and disappointment to millions of consumers who will pay extra for speeds they cannot use for fear of running over their data cap.

Sources Appendix

The numbers used to calculate the charts in this paper are necessarily approximations. Compression standards can result in significant differences in file sizes of a single source file, and between different source files. As a result, the calculations in this paper should be understood as informed estimations. To put it another way, your mileage may vary.

However, while it might take a specific user at a specific time 22 minutes or 27 minutes to reach the Verizon data cap, the larger conclusion rings true. Data caps discouraging using 4G networks for the types of applications that benefit most from 4G networks. Strict data caps directly undermine the justification for paying for 4G networks in the first place.
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Chart 1: ISP Data Caps

This chart simply compares the size of Comcast's existing data cap with the cap offered by Verizon and AT&T.

Chart 2: Minutes of Continuous Use Before Hitting Cap

AT&T's claimed network speeds of 6 Mbbps can be found here: *Just How Fast is AT&T 4G?*, AT&T, *available at* http://www.att.com/esupport/article.jsp?sid=KB115947#fbid=gFI2qtBBQCV

Verizon's claims of between 5 Mbps and 12 Mbps can be found here: *What is 4G?* Verizon, *available at* http://network4g.verizonwireless.com/#/whatis4g.

Chart 3: Number of Files Downloaded or Uploaded Per Month Before Hitting Cap

Approximate sizes for iTunes content can be found at *iTunes Store: Download times may vary*, Apple, *available at* http://support.apple.com/kb/HT1577.

Data on the average size of a 10 minute HD video captured on a mobile phone was derived from Justin Horn, *iPhone 4 picture and HD video sizes confirmed, gets upgraded video compression*, WhenWillApple.com, (June 18, 2010) *available at* http://whenwillapple.com/blog/2010/06/18/iphone-4-picture-and-hd-video-sizes-confirmed-gets-upgraded-video-compression/.

Chart 4: Hours of Streaming Media Per Month Before Hitting Cap

Average Netflix streaming rate was taken from data released from Netflix in a blog post titled *Netflix Performance on Top ISP Networks*, on May 31, 2011 and available here: http://techblog.netflix.com/2011/05/netflix-performance-on-top-isp-networks.html
The Netflix data contained streaming rates for a number of ISPs. This paper uses recent streaming rates on the ISP Clearwire, which is a wireless ISP that advertises itself as a 4G provider. Clearwire is the lowest performing ISP in the Netflix dataset. As a result, using data from another ISP would decrease the amount of time before hitting the cap.

Data on recommended bitrates for streaming to iPad and iPhone is drawn from Apple Technical Note TN2224, *Best Practices for Creating and Deploying HTTP Live Streaming Media for the iPhone and iPad*, available at http://developer.apple.com/library/ios/#technotes/tn2224/_index.html.

High quality music is defined as music streamed at 320Kbps, an option offered by services such as Spotify and MOG.